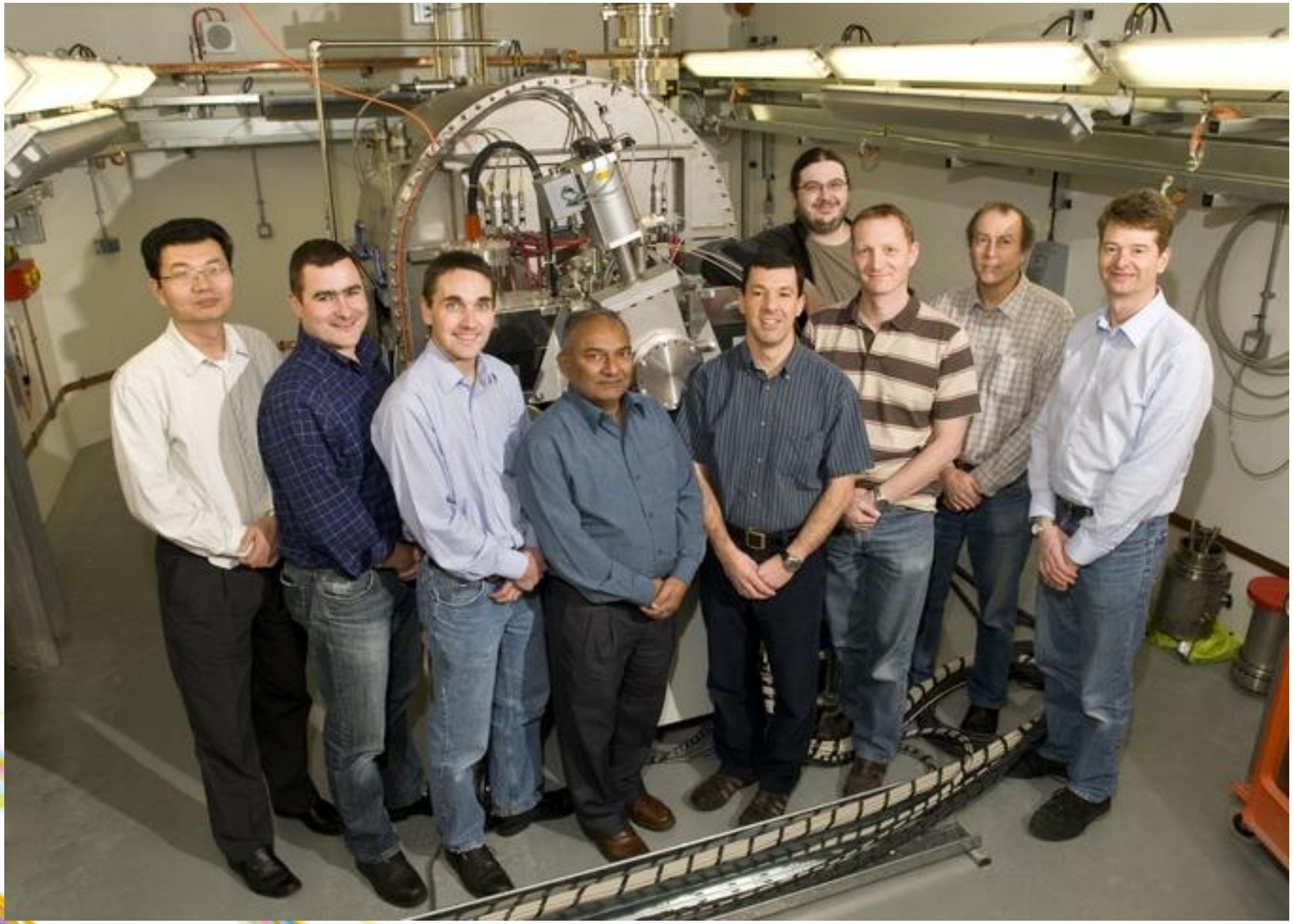
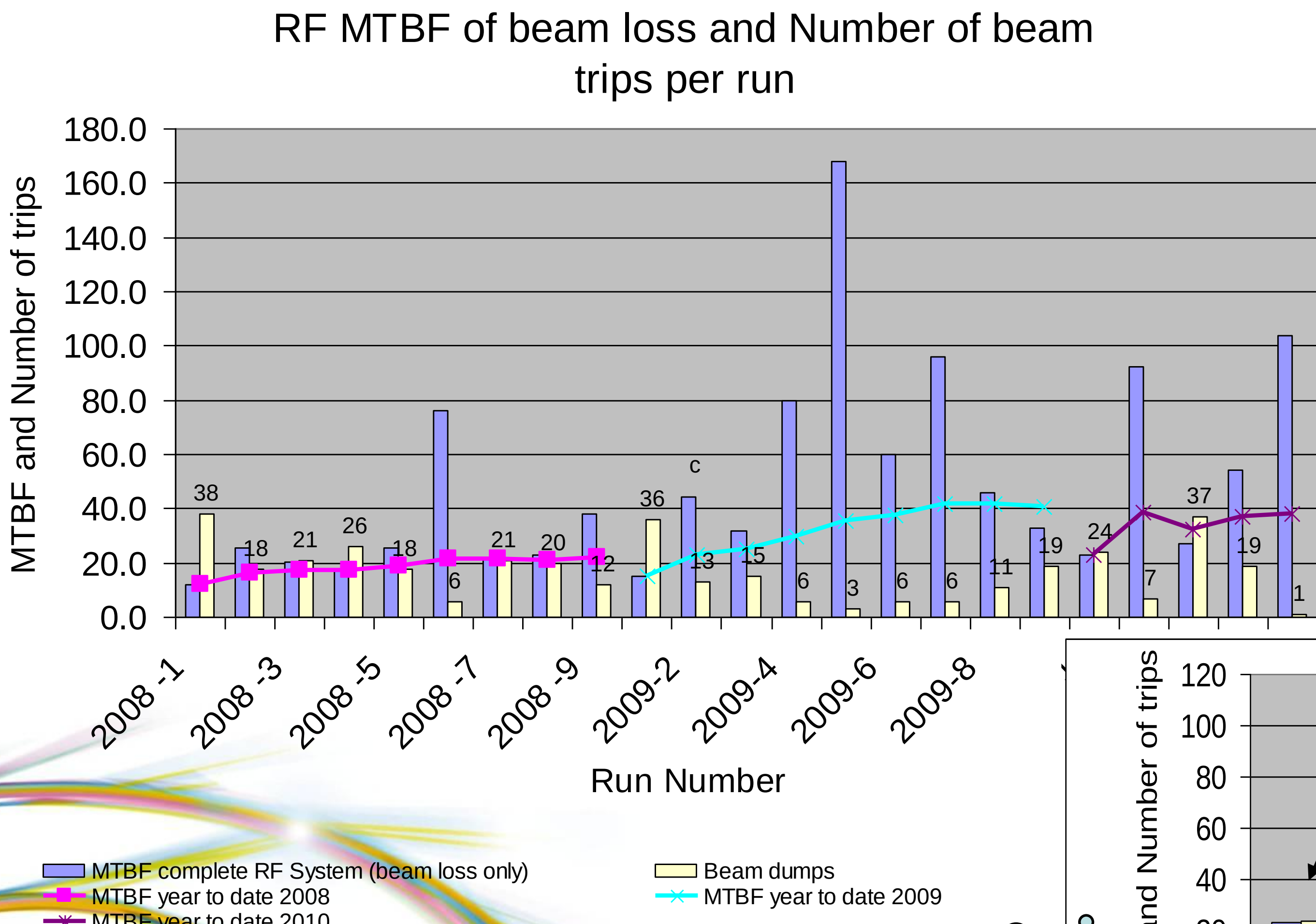
Review of Diamond SR RF Operation and Upgrades



Morten Jensen
on behalf of
Diamond Storage Ring RF Group

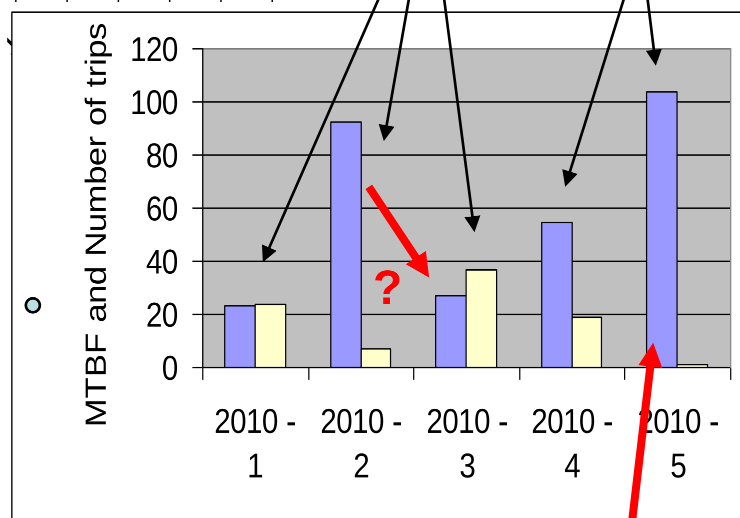
Agenda

- Stats
- X-ray and LN2 pressure results
- Cavity Failure
- Conditioning in the RFTF
- Cavity Simulations
- IOT Upgrade
- Helium Refrigerator update



Cavity 1 only
1.8 MV typical
Many trips in
Run 1 to find
acceptable
voltage

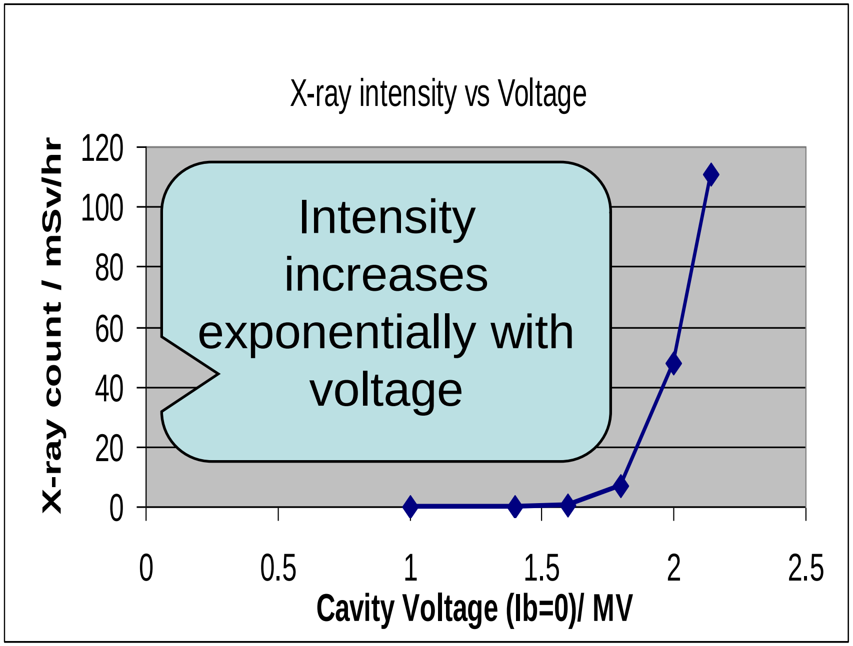
Cavity 3
Installed

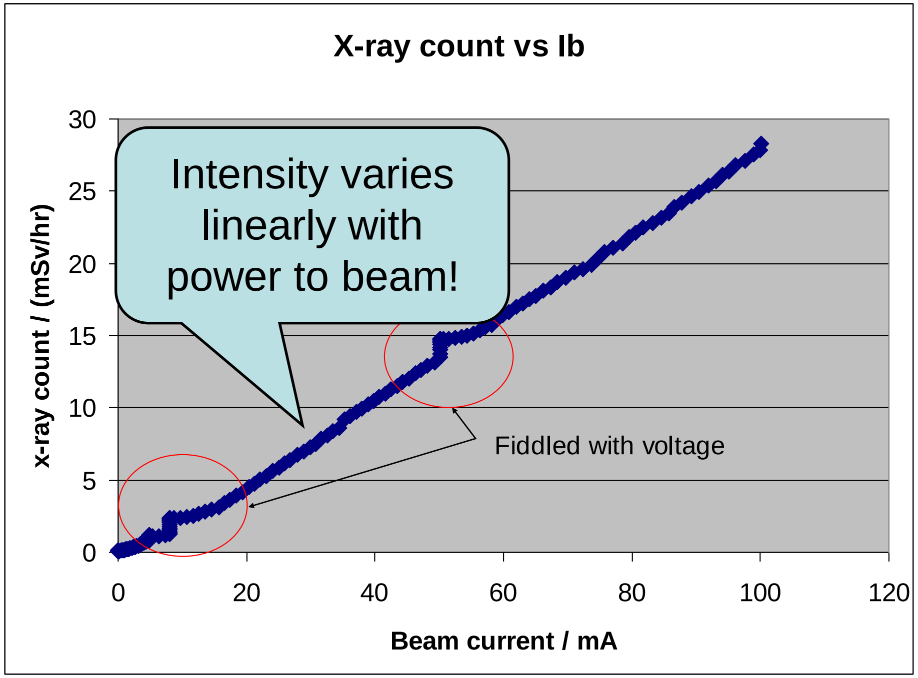


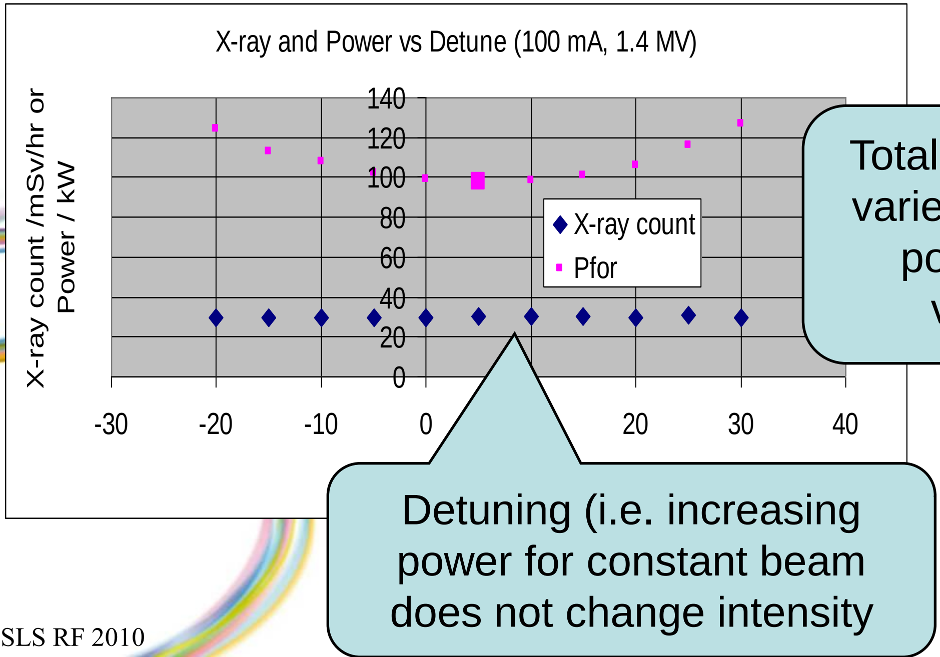
Partial Run

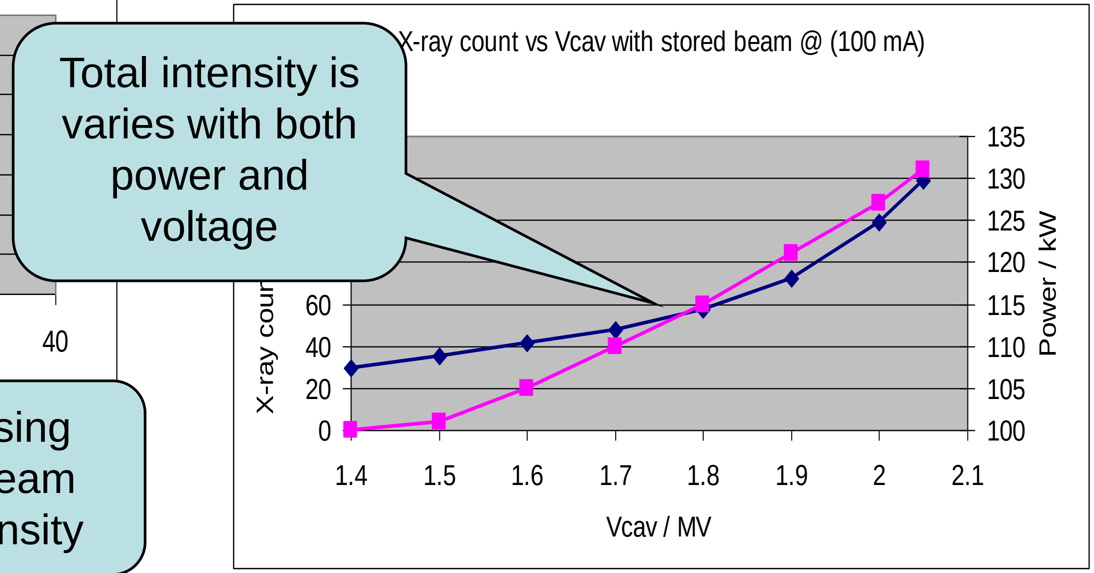
Overall MTBF STILL
dominated by Cavity trips

X-ray measurements on the cavities

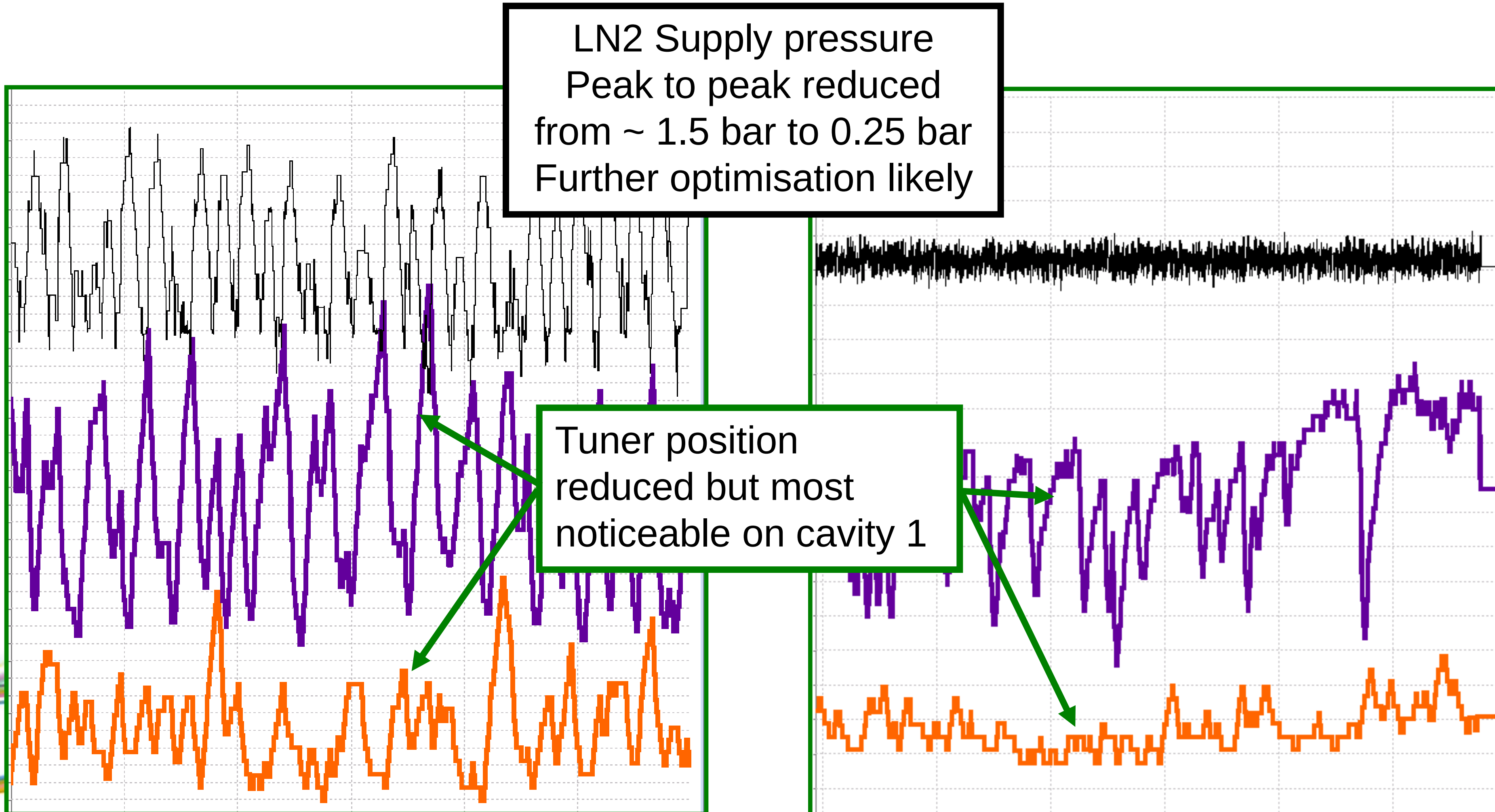








LN2 supply pressure stability improved



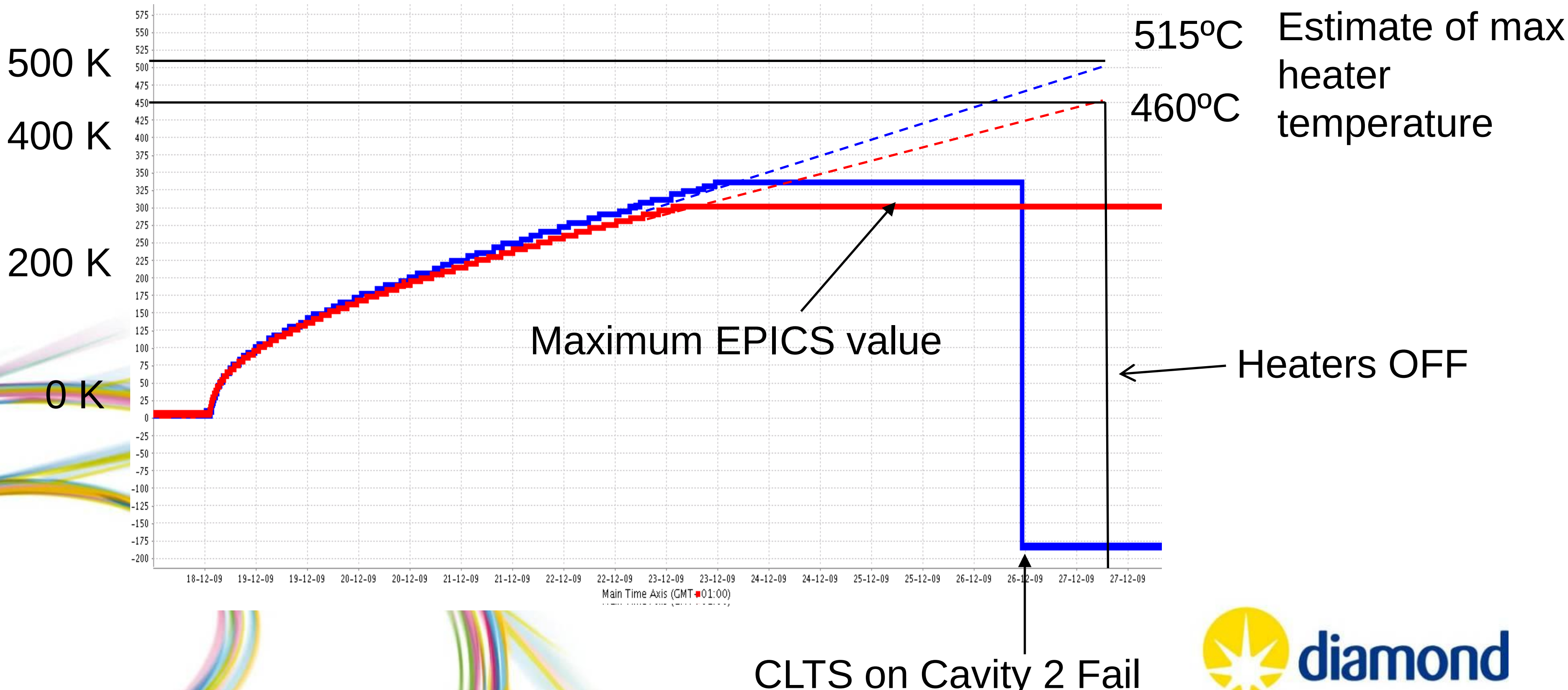
LN2 Pressure stability improved by the installation of pressure and level control valves on the LN2 supply tank

Ongoing investigation to determine residual perturbation

Cavity 2 Failure

Cavities 1 and 2 installed and being warmed up over Christmas.
Warming up the cavities requires the use of electrical heaters.
Procedure and Manual did not include turning off heaters.
Heaters were not interlocked.
→ Heaters were left on!

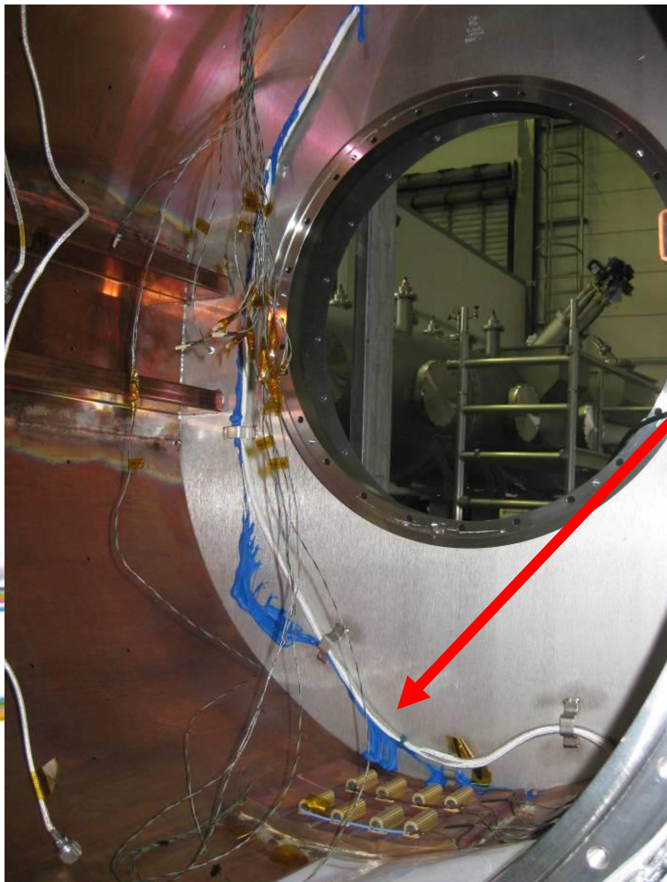
First sign: Leak from helium can to insulation vacuum



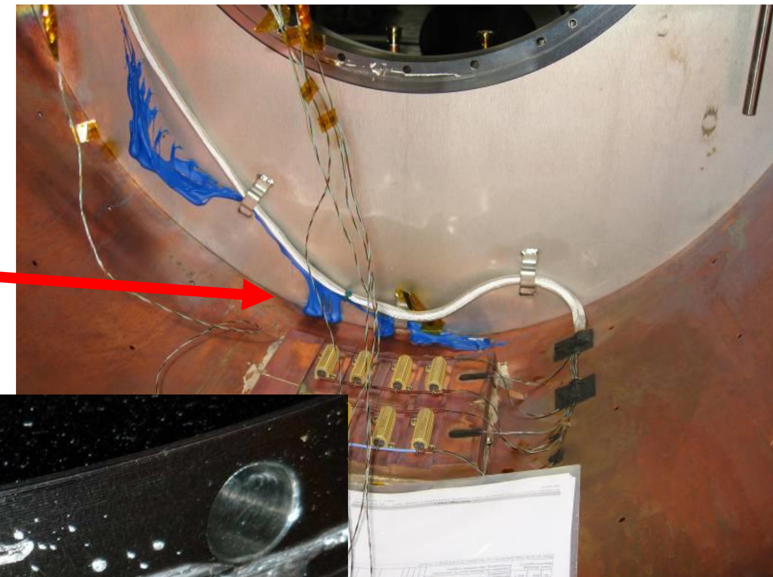
Cavity 2 Failure

Investigation revealed:

- Both Helium level sensors not functioning
- Main pickup and waveguide coax cables have short circuit (both in helium can).
- Some of the temperature sensors on the niobium cell have been unsoldered.



Helium level probes with blue ‘plastic’ insulation which has melted

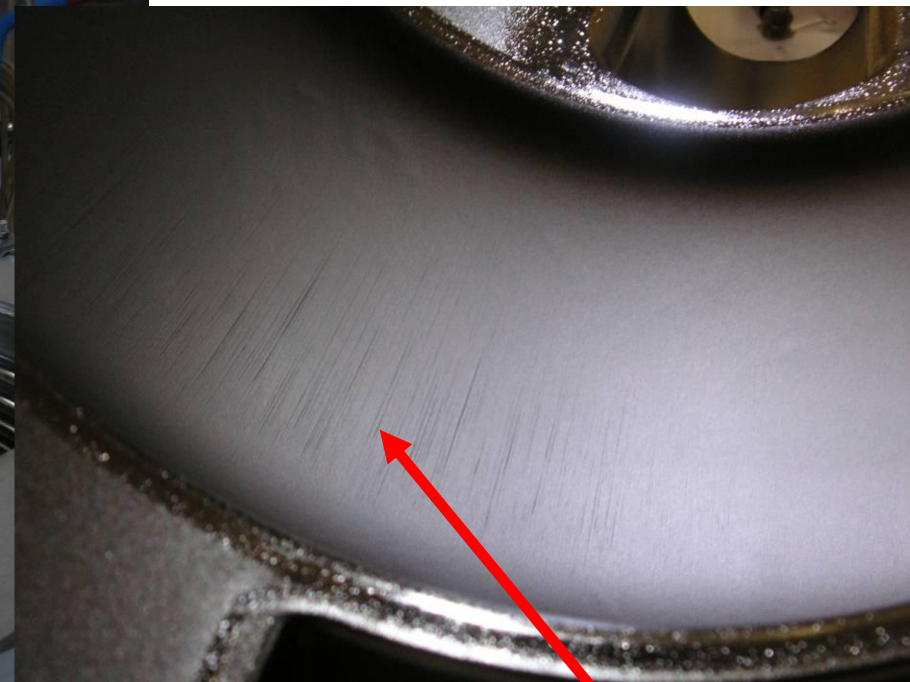


Vacuum seal has failed and indium has melted

Cavity 2 Failure

Additional observations not related to the increase in temperature

Bellow section has distorted.



Radial groove from original BCP etch

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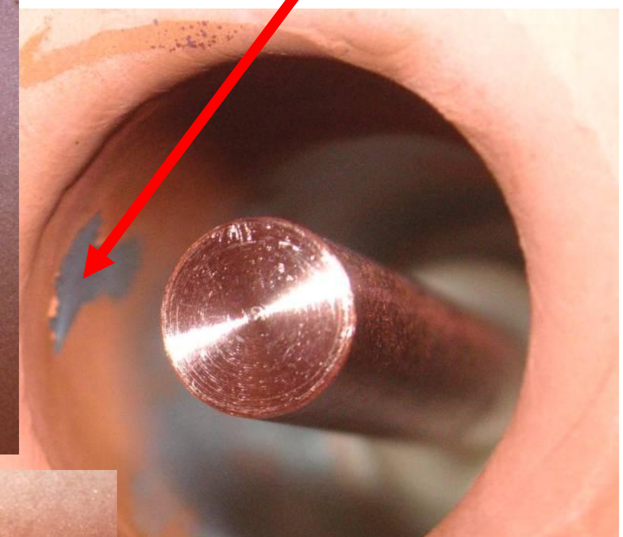
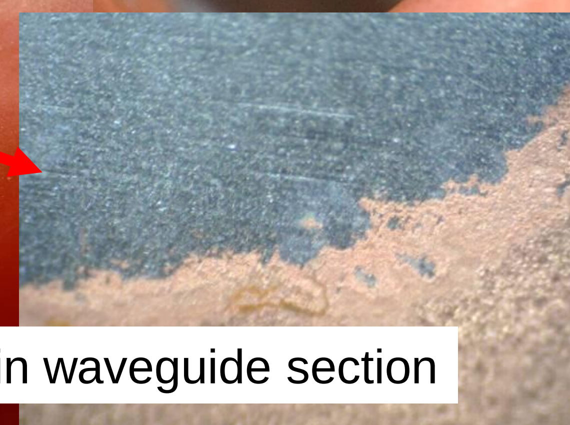
Copper Plating Problems

Peeling copper plating on most pickups and missing plating inside the cups

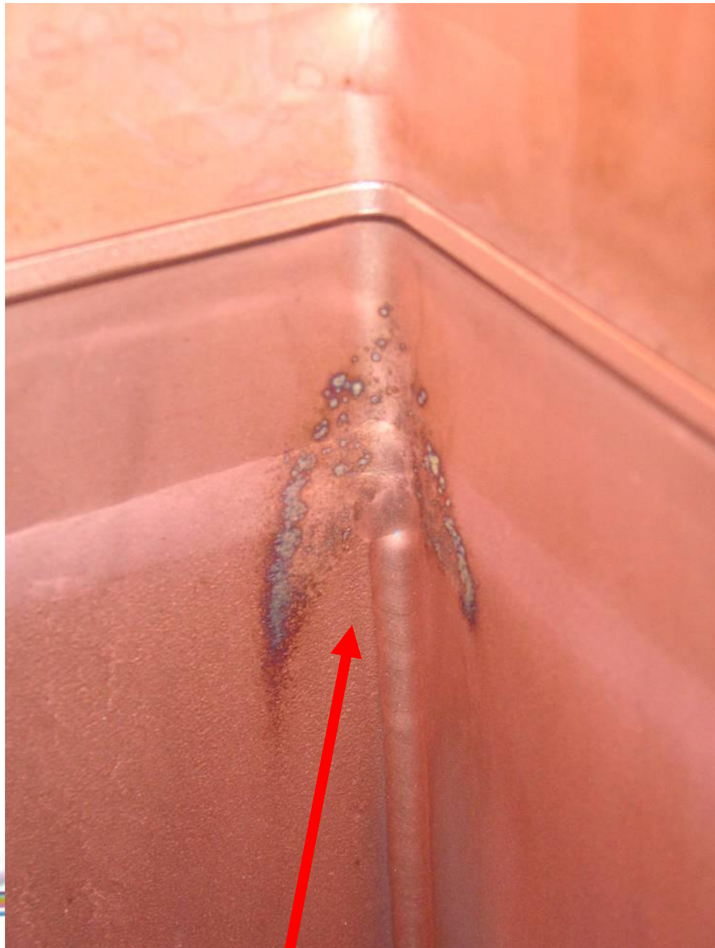


Marks on copper plating in the waveguide.
Staining or tracking marks?



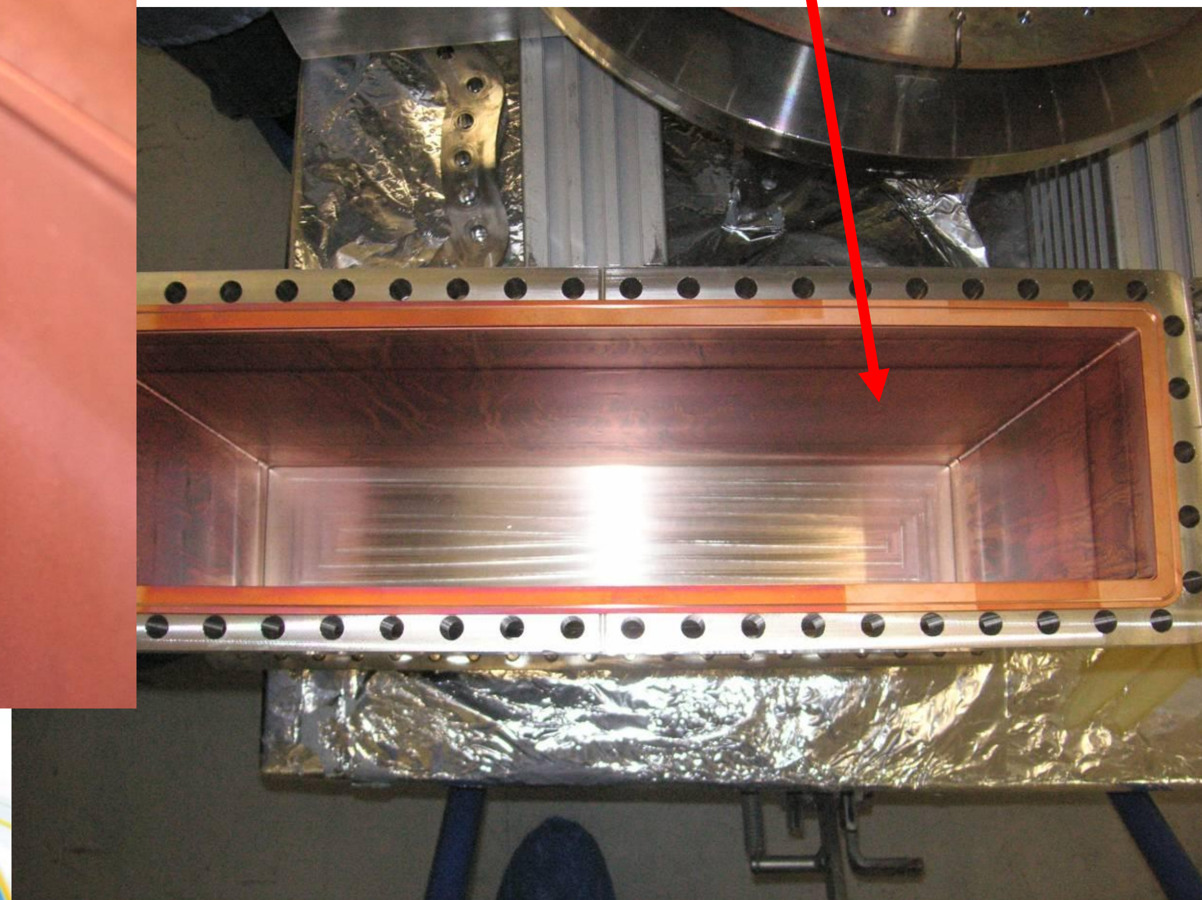
Damaged plating in waveguide section

Copper Plating Problems



Staining or damaged plating in the corners of the waveguide

Discolouration of waveguide components and of the gasket



5 - 8 January:
Cavity 2 removed from tunnel and make up vessel installed.

9 - 10 January:
Cavity 1 cooled down – noticed that no level sensors were usable and RF pickup cables short circuited.

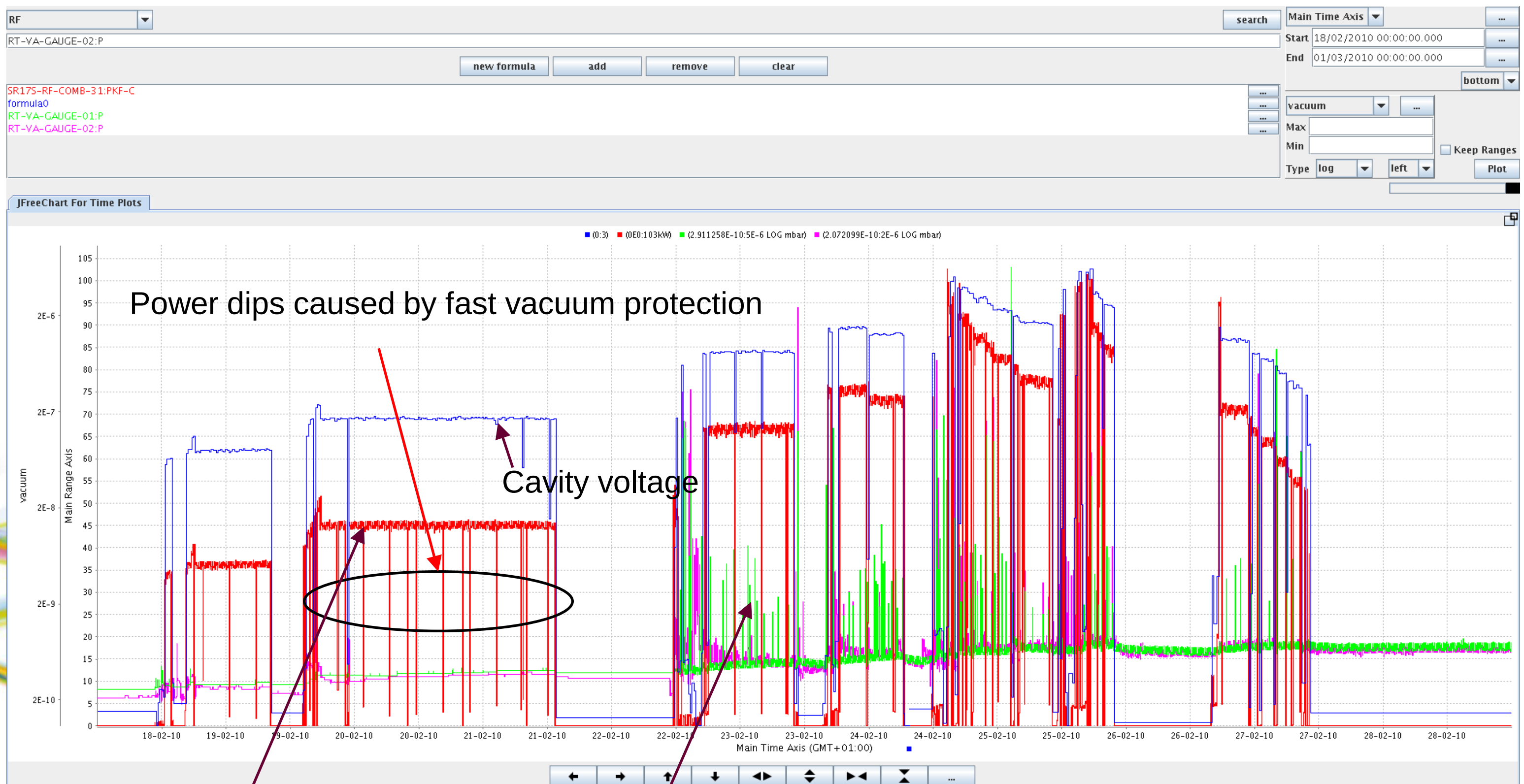
10 January (Sunday night):
Controlling level by controlling total inventory. RF control via spare RF cable on the beam pipe.

11 January:
Machine start-up

Then move on to Radiofrequency Test Facility commissioning, cavity installation and conditioning in RFTF.

Conditioning of cavity 3 inside RFTF

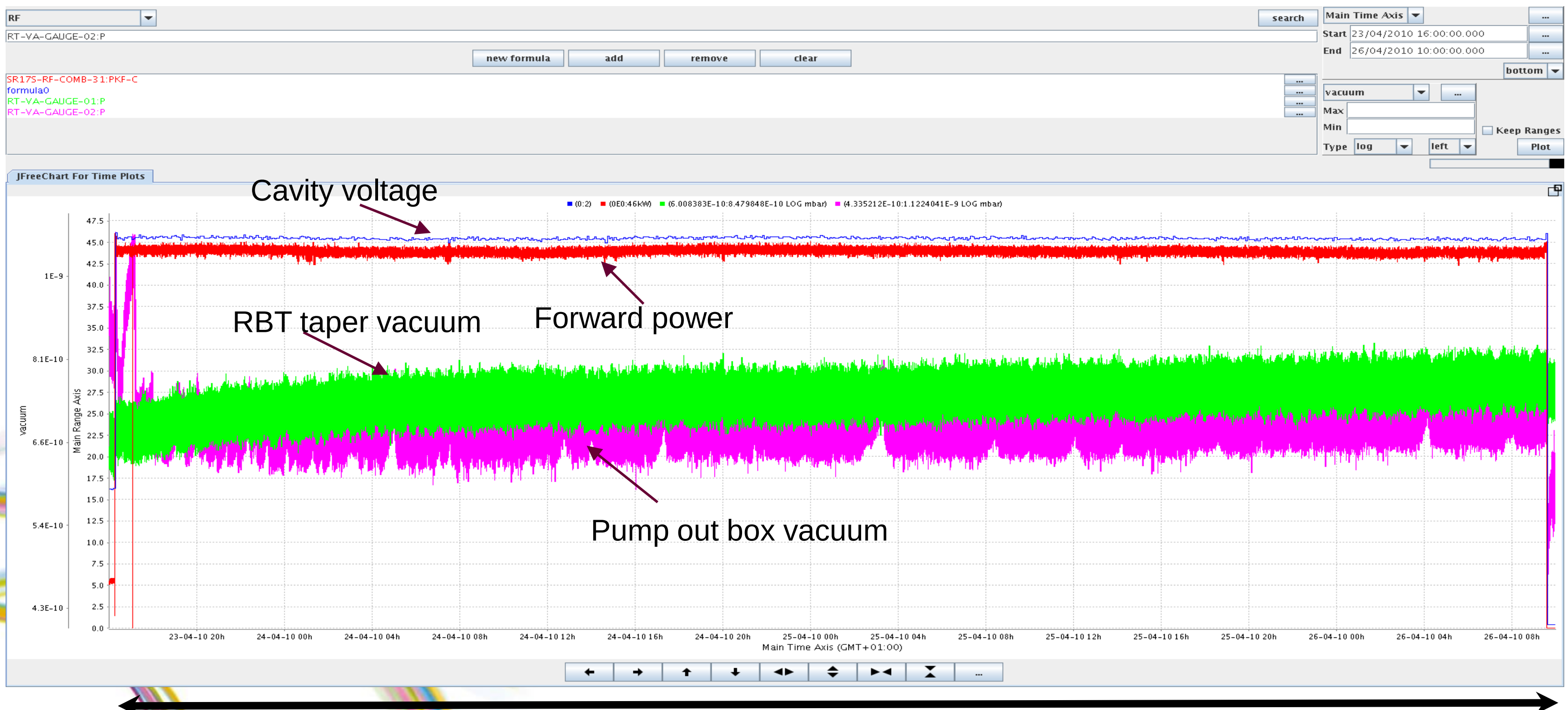
Initial conditioning in February 2010. Gradual increase in cavity voltage and power dips caused by fast vacuum protection during conditioning can be seen.



Forward power

Vacuum spikes during conditioning

Soak test in April. Time scale is kept the same as last slide. Improvement in long term performance can be seen clearly.



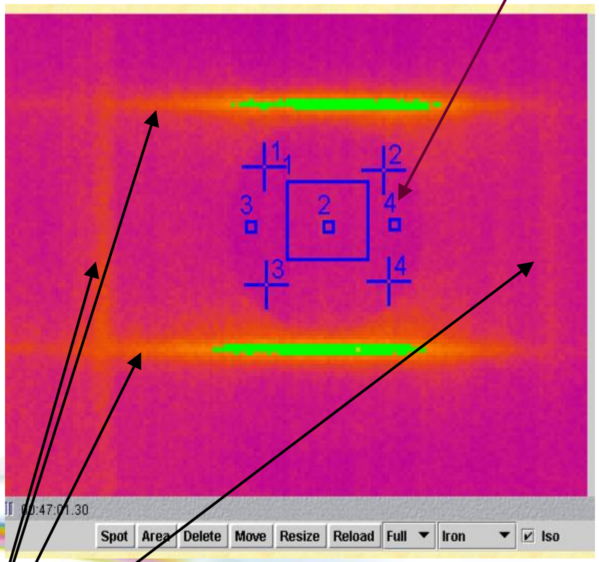
~ 3 days

Infrared pictures of RF window during conditioning

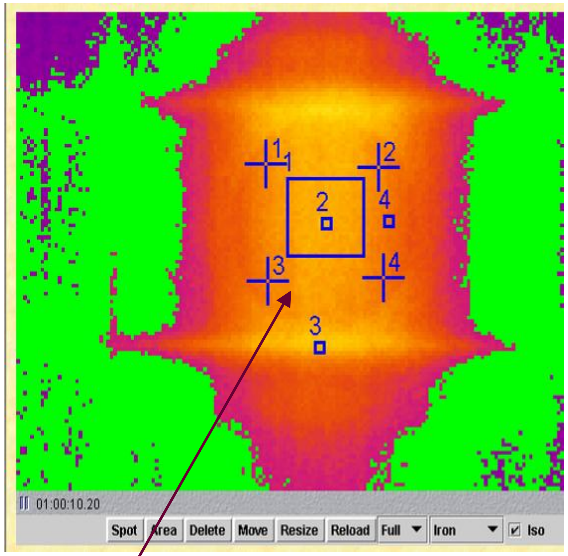
84KW forward power, cavity on resonance

55KW forward power, detune angle -60degree

RF Window 28 degree

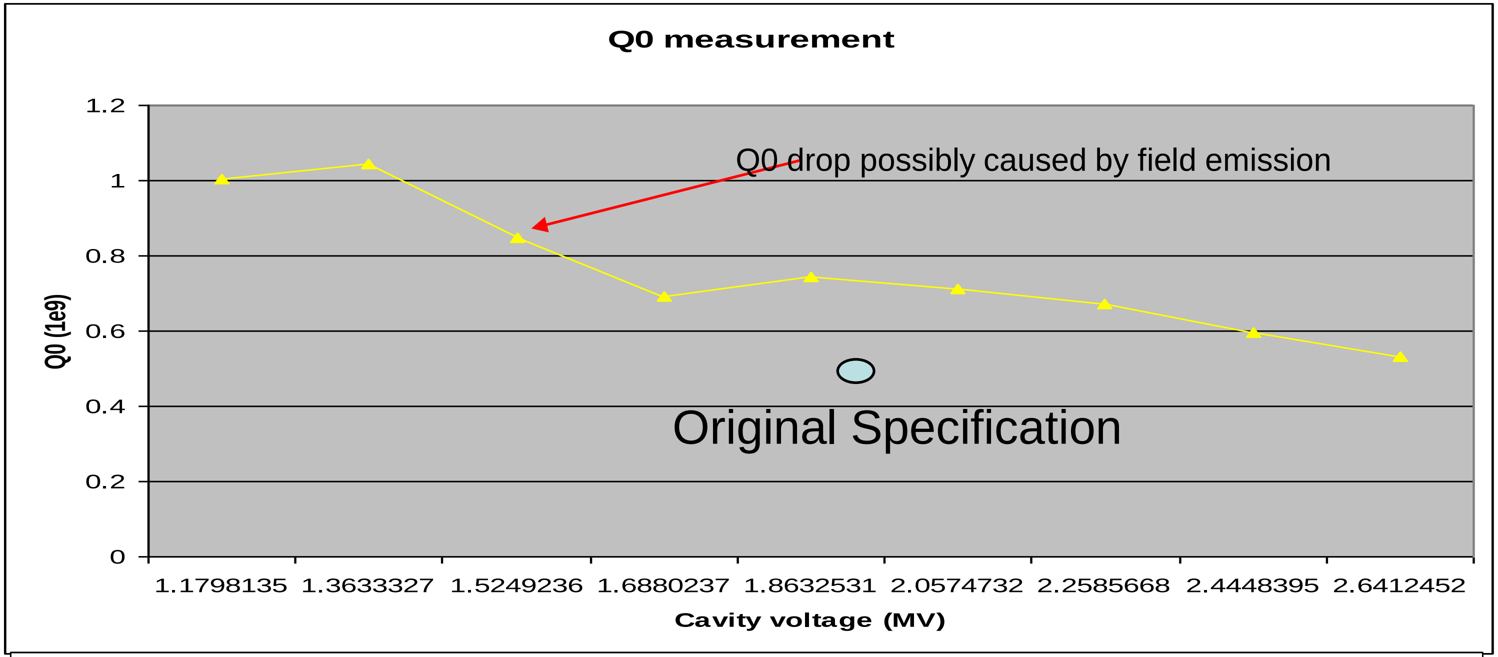


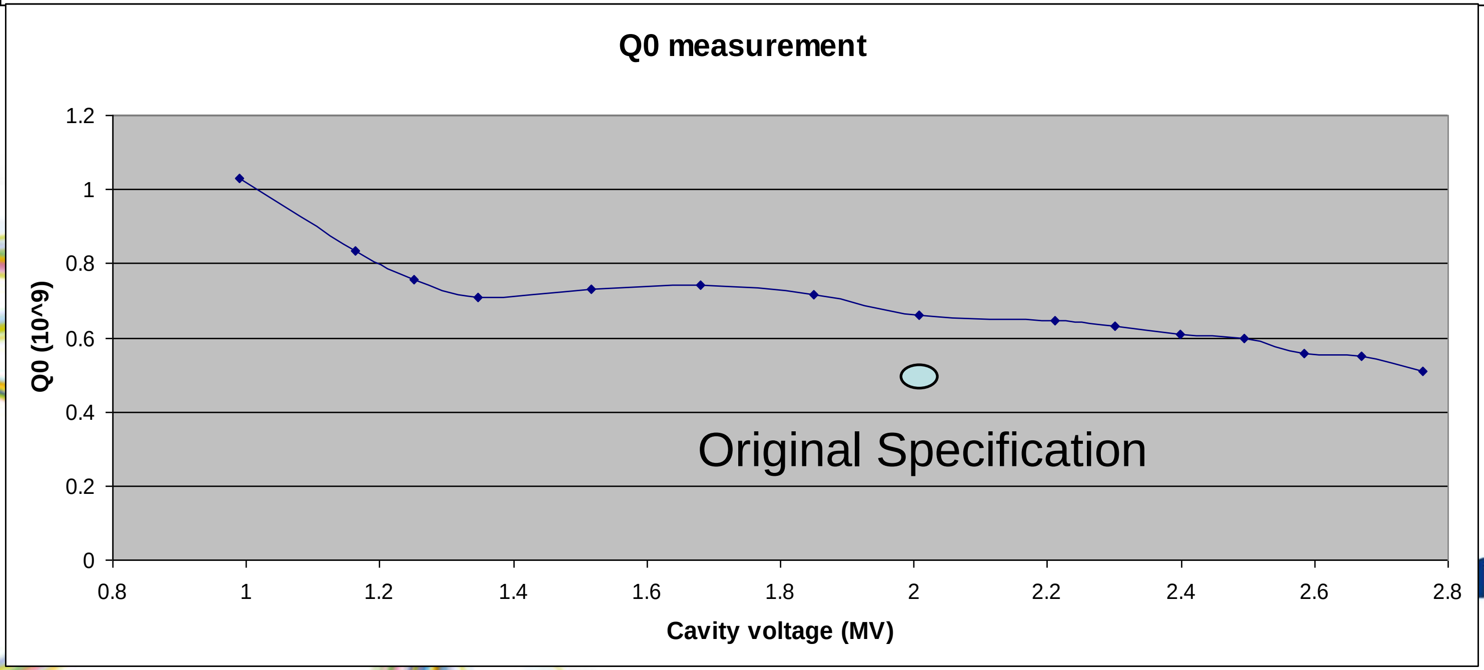
Waveguide walls



Window heated up to 30 degree

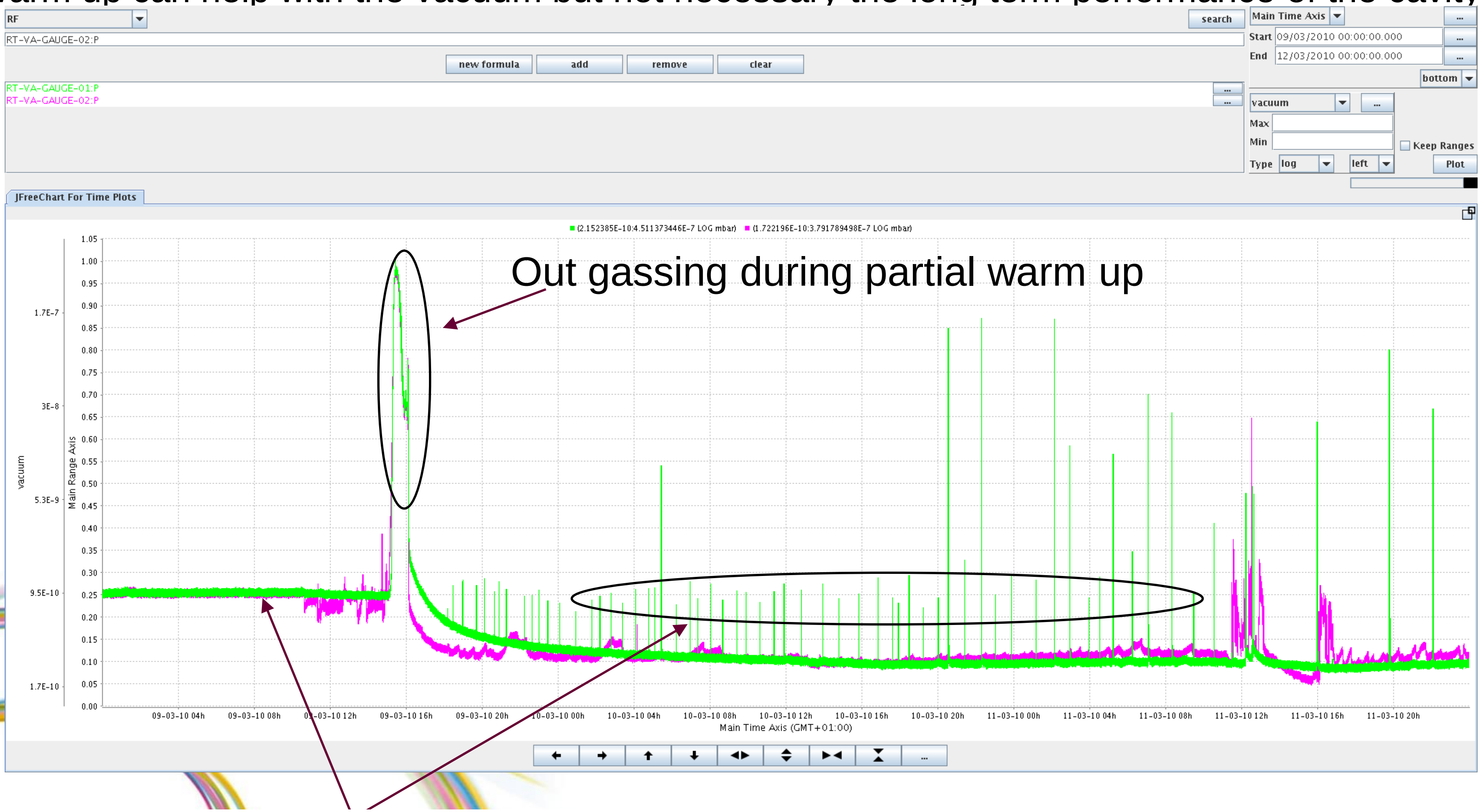
2 Q0 measurement showing Q0 drop at low voltage





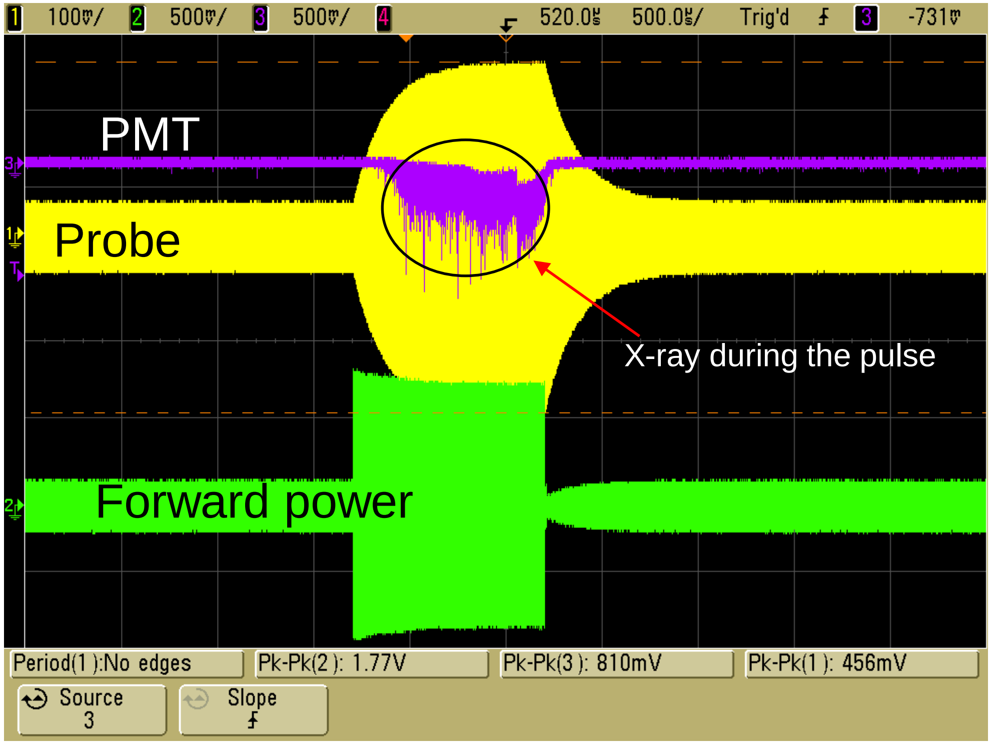
Cavity partial warm up experiment

Partial warm up to 28K to release hydrogen.
Warm up can help with the vacuum but not necessary the long term performance of the cavity

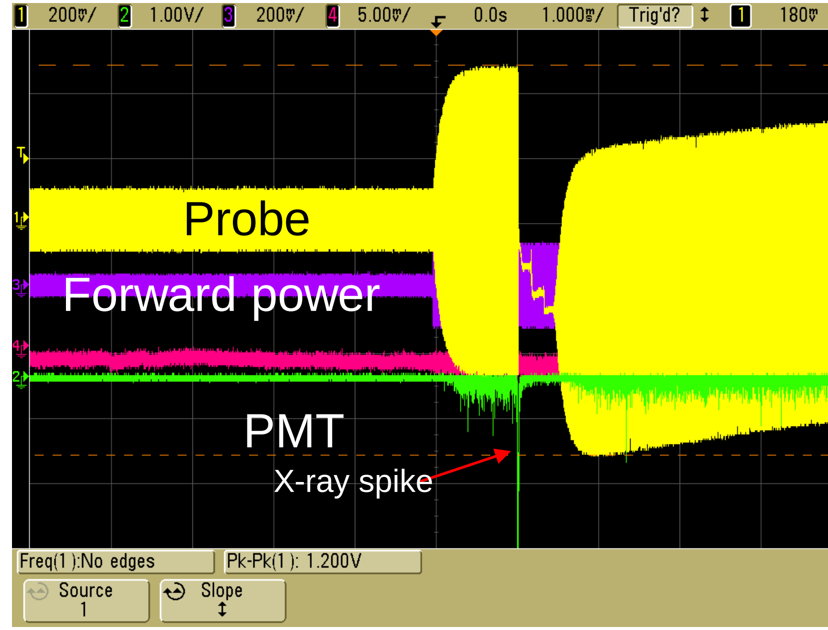


Vacuum is better after partial warm up. But many vacuum spikes appeared.
Some spikes triggered protection.

PMT signal during conditioning

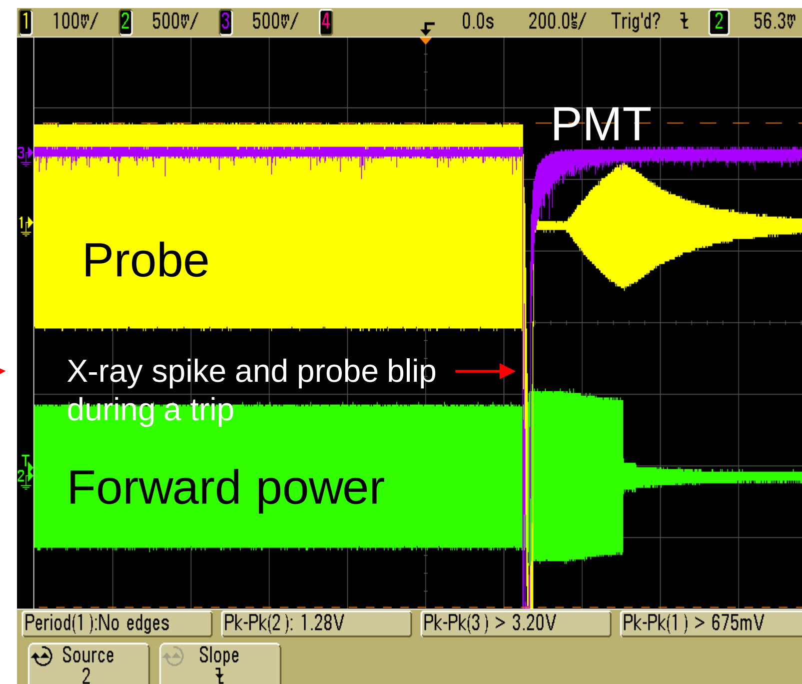


PMT signal showing probe blip



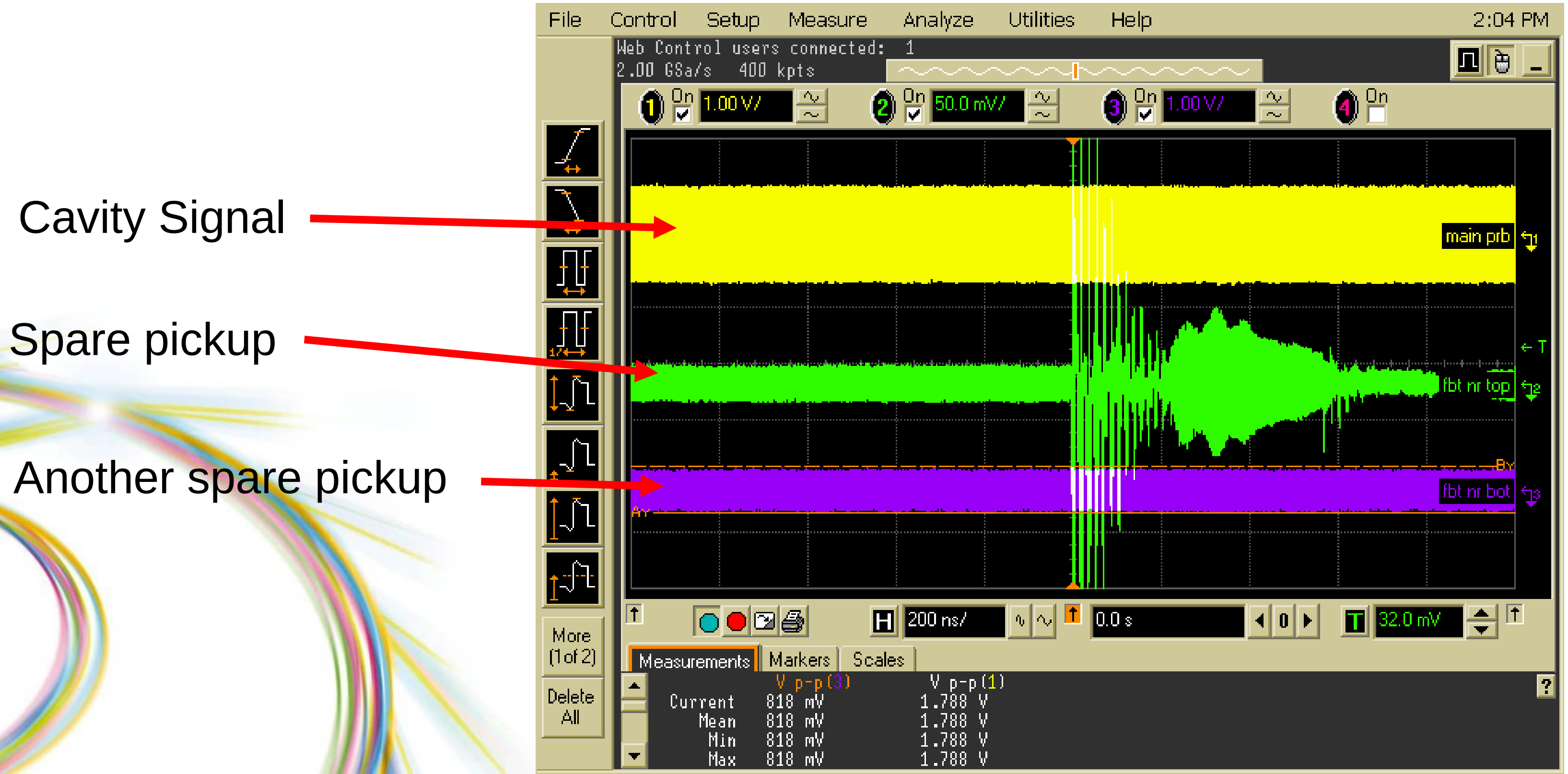
X-ray starts around 1.5MV.

Beam trip

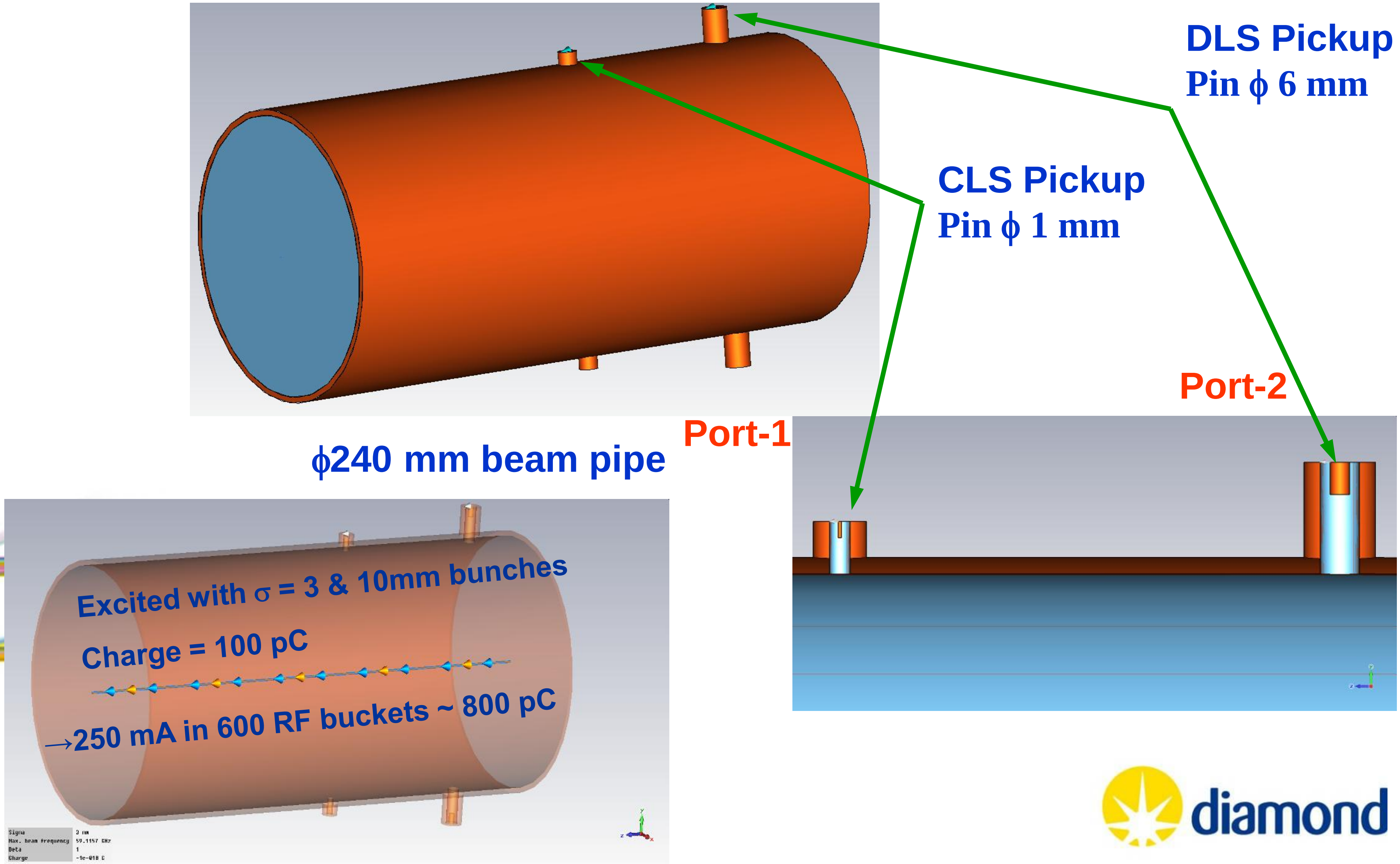


Probe problem

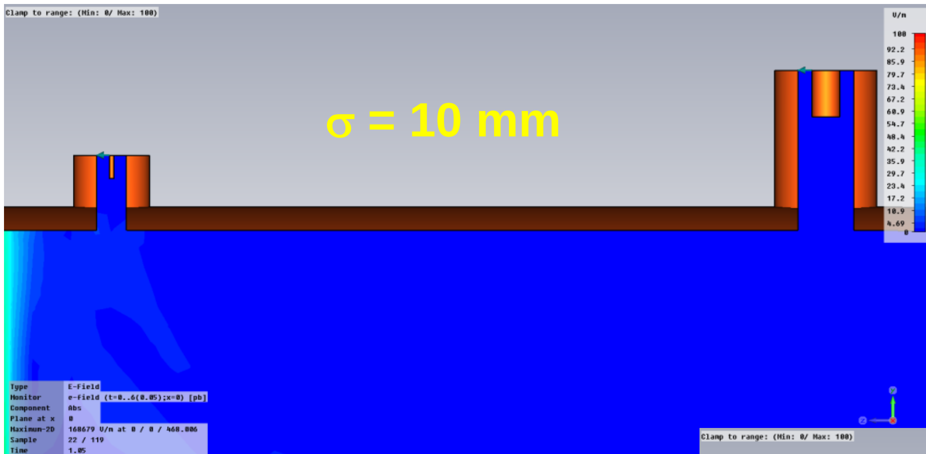
1. Main probe and e- pickup have failed.
2. Cavity 2 and 3 both suffer probe blips. Cavity 1 under investigation.
3. Probe blips happen with and without beam.
4. Probes don’t have blips at the same time.
5. Probe blips don’t always trip the beam.
6. Very high amplitude.
7. Not successful to filter it out. (Band pass filter, DC block)
8. Not successful with bias voltage.



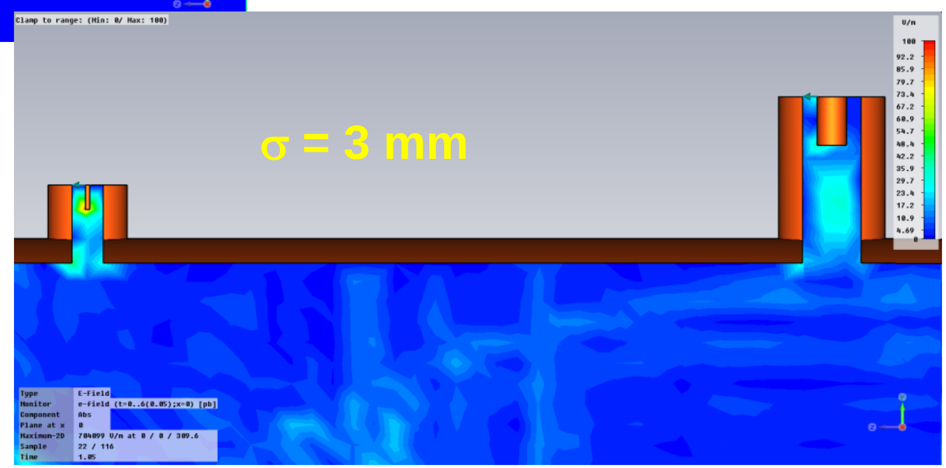
Observed probe ‘blips’ kicked off wake field simulation of the RF probes



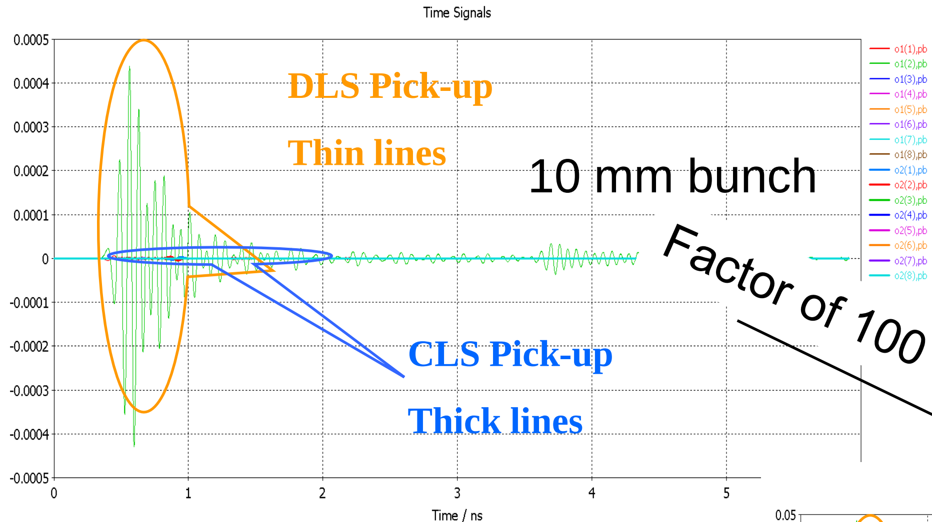
Snapshot E-Field at t=1.05 ns for 10 & 3 mm bunches, yz-plane



The maximum field value is clamped at 100 V/m in both cases.

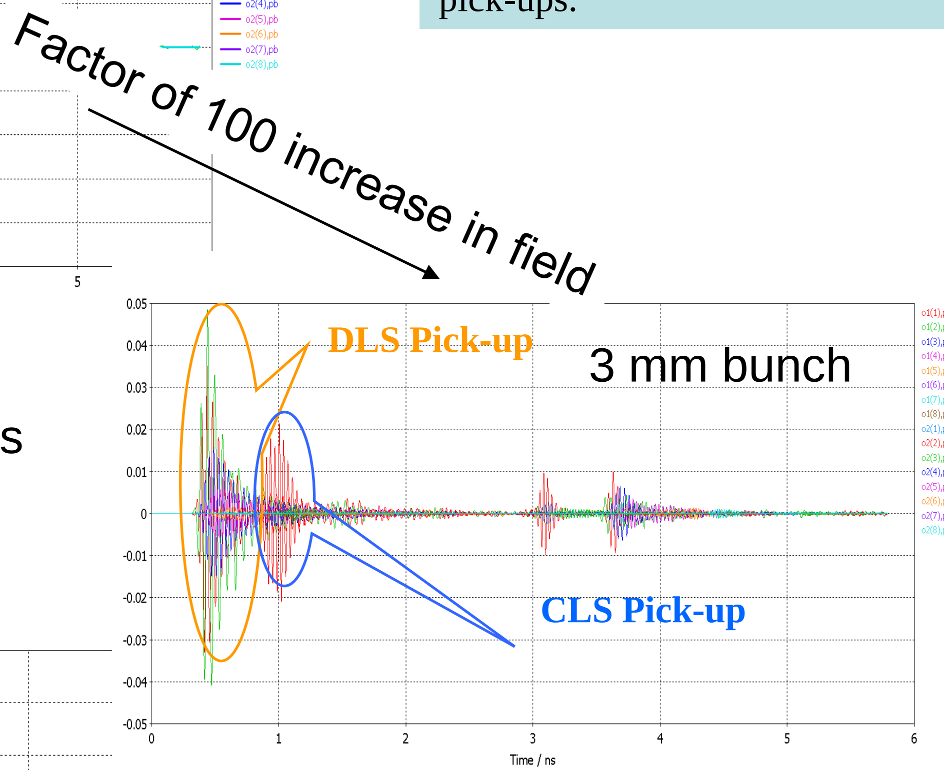


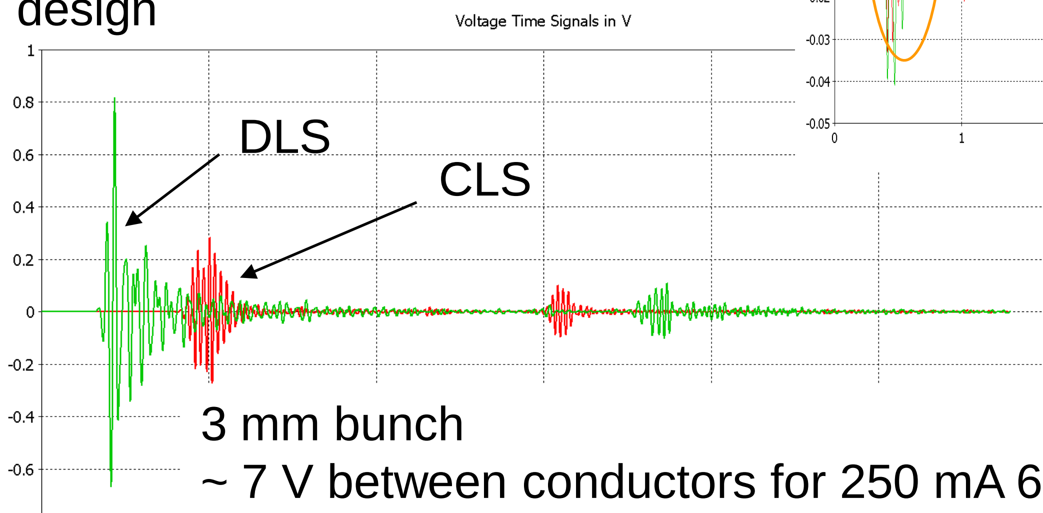
The field at the DLS pick-up has decayed by the time the bunch passes the CLS pick-up and therefore appears to be lower.



The EM signal induced by the beam propagates in many modes through the pick-ups.

For 10 mm bunch the voltage induced between the conductors is very low at 0.003 V for DLS pickup and lower still for CLS design

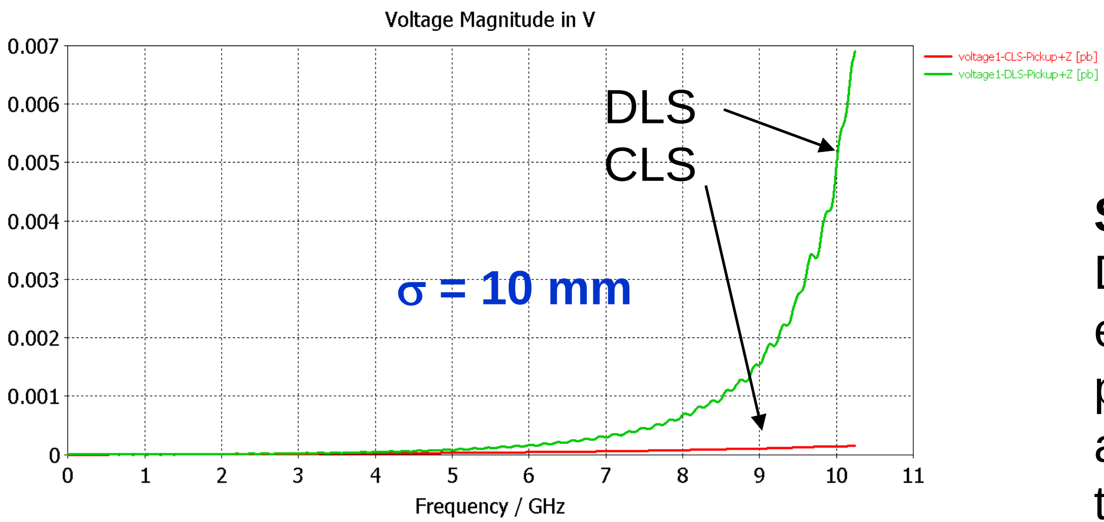




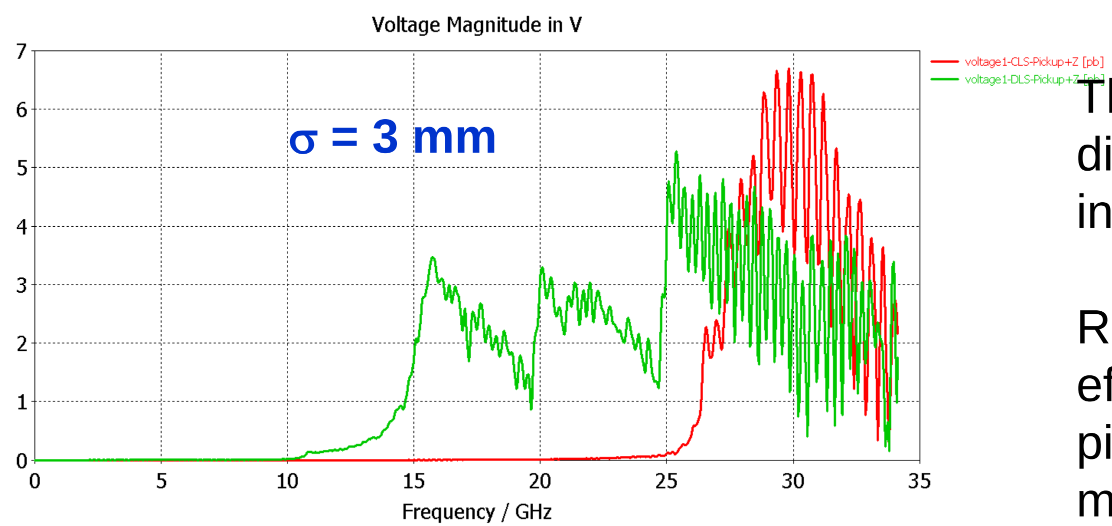
3 mm bunch

~ 7 V between conductors for 250 mA 600 bunches. DLS probe has 4 x CLS voltage

Frequency content of Voltage Signal



Summary:
Diamond beam (σ =3 mm) excites stronger signal in the pick-ups compared to the CLS and CESR (σ=10mm) beams for the same charge.



The DLS Pick-ups have larger diameters and so the signal induced will be stronger.

Risk of breakdown and wakefield effects are greater for the DLS pickup but unlikely to be the main reason for our beam trips.

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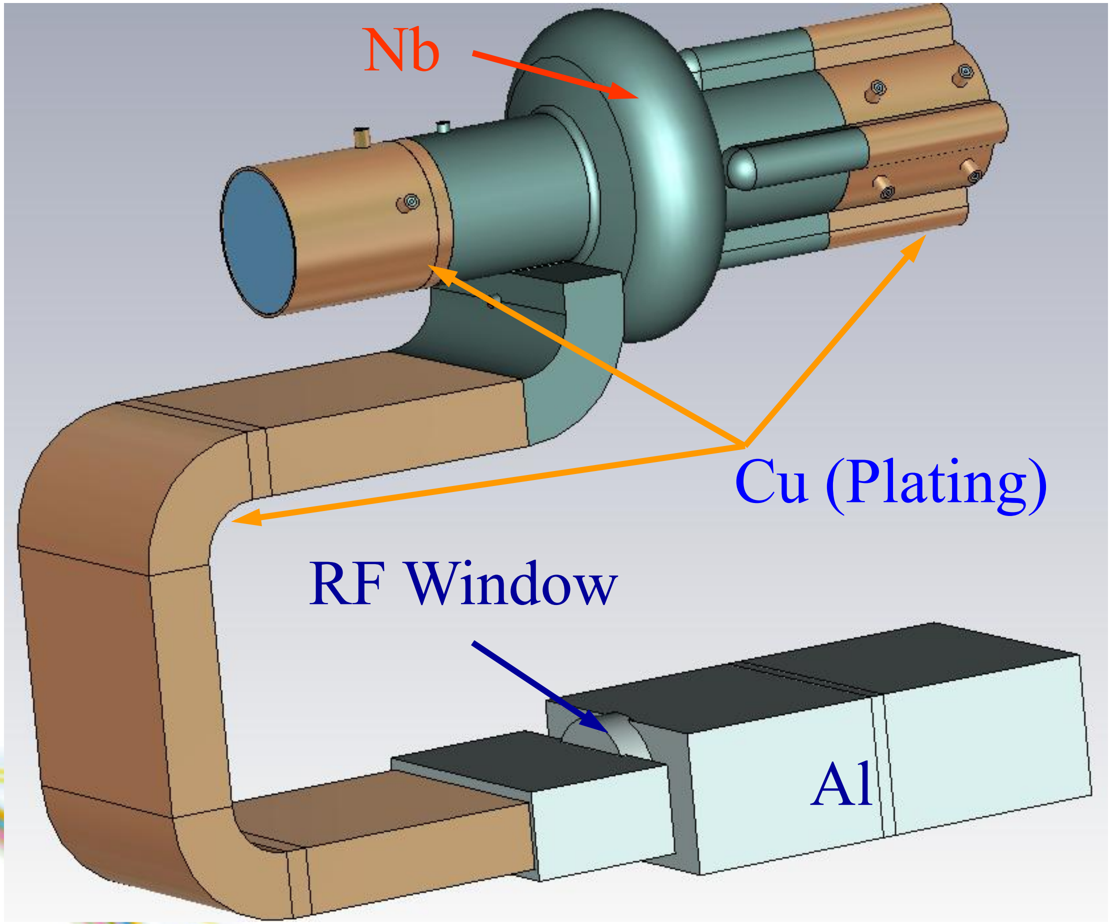
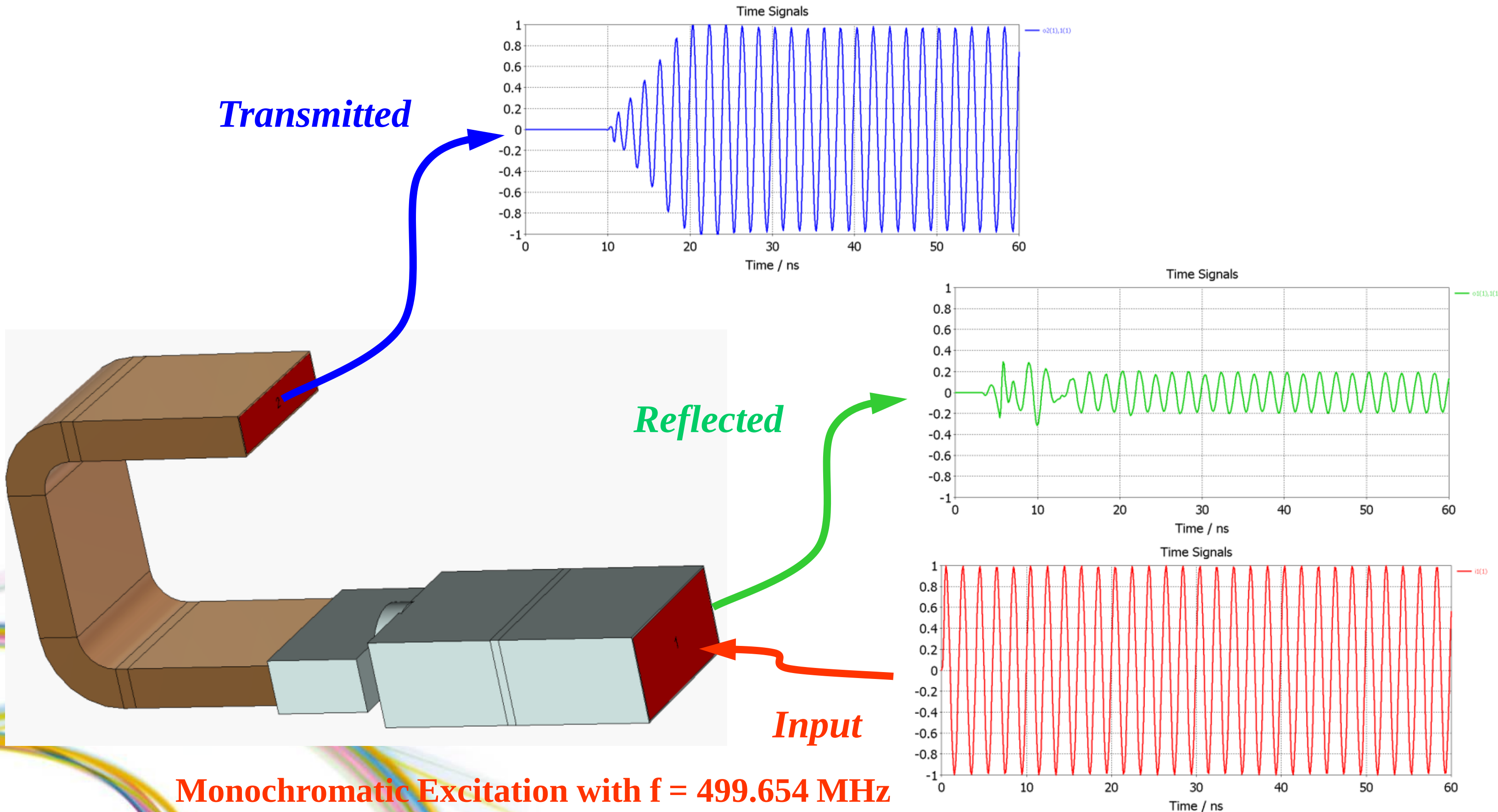
Multipactor simulation of the DLS Cavity & Waveguide

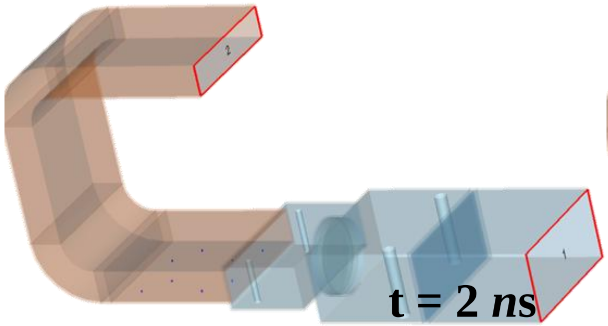


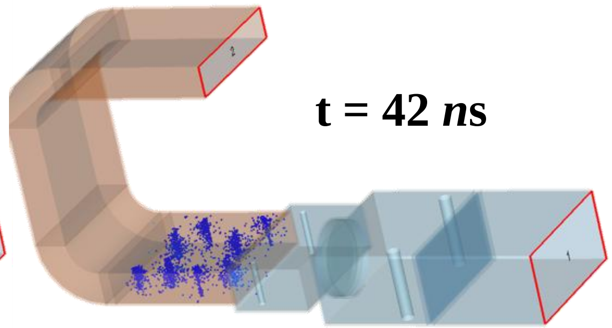
To establish TW fields in the waveguide

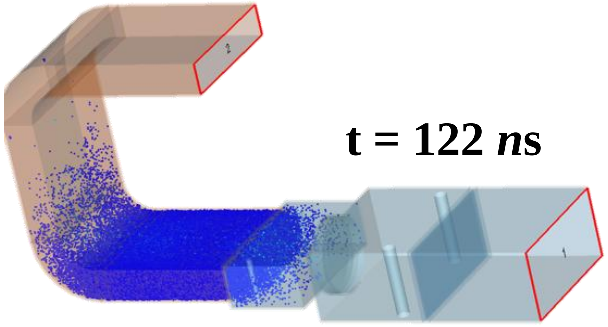


Monochromatic Excitation with f = 499.654 MHz

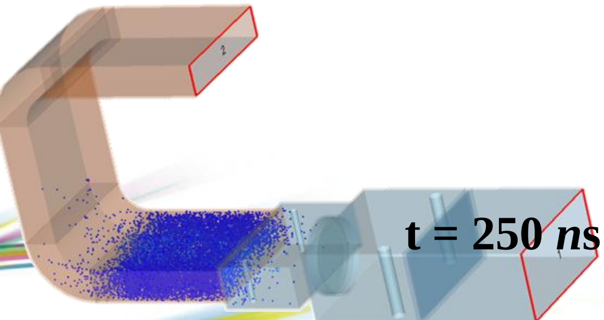
Development of Multipactor, P = 200 kW PIC Solver

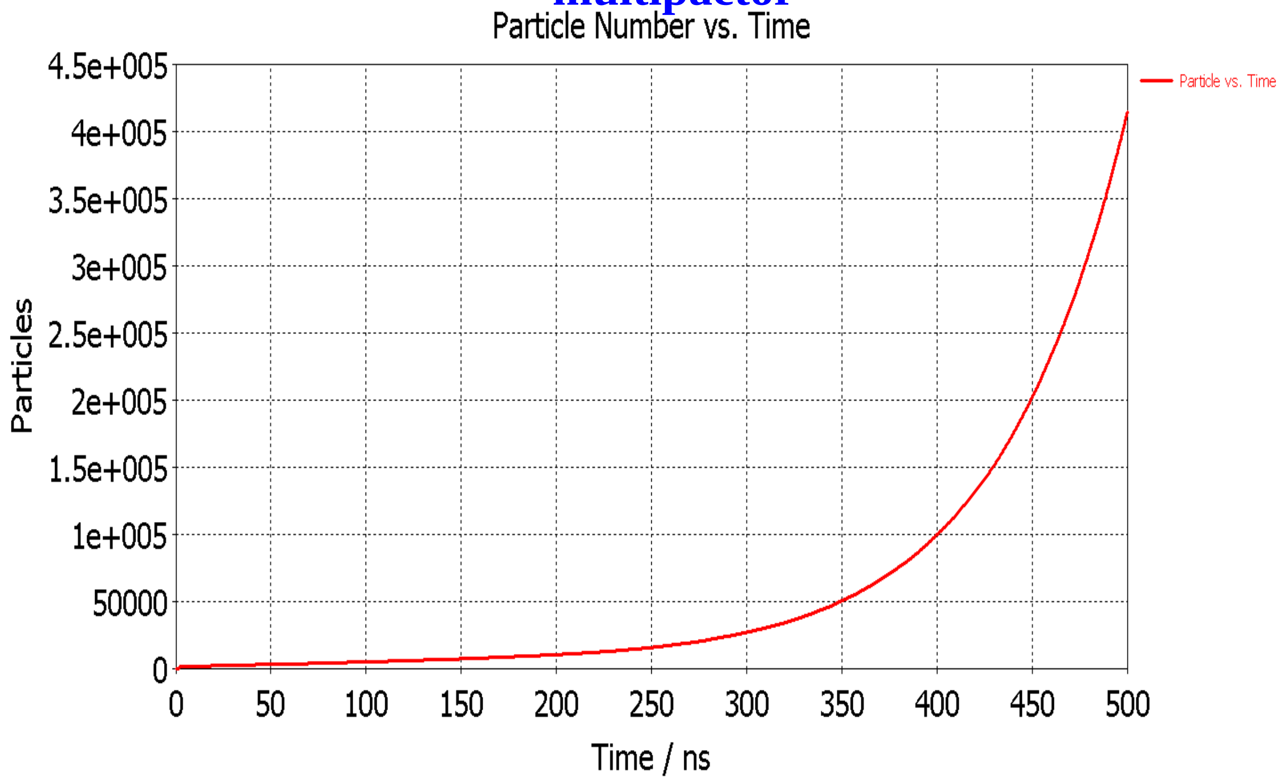






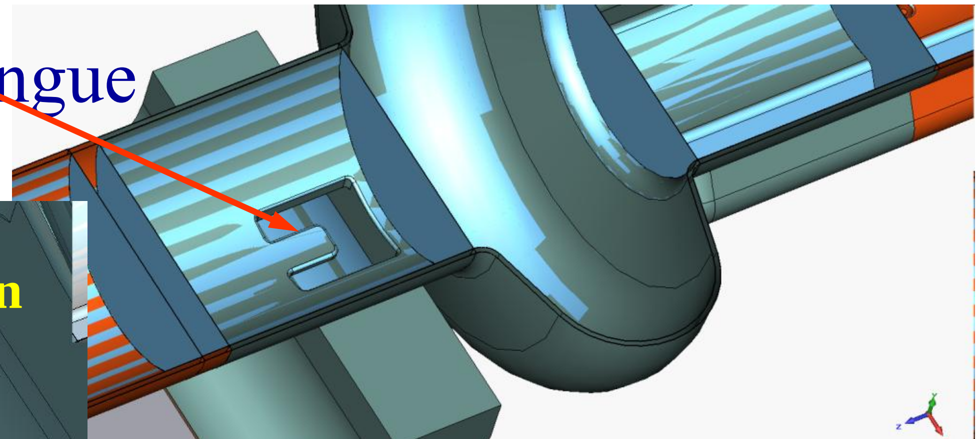
Exponential growth of number of particles indicate multipactor



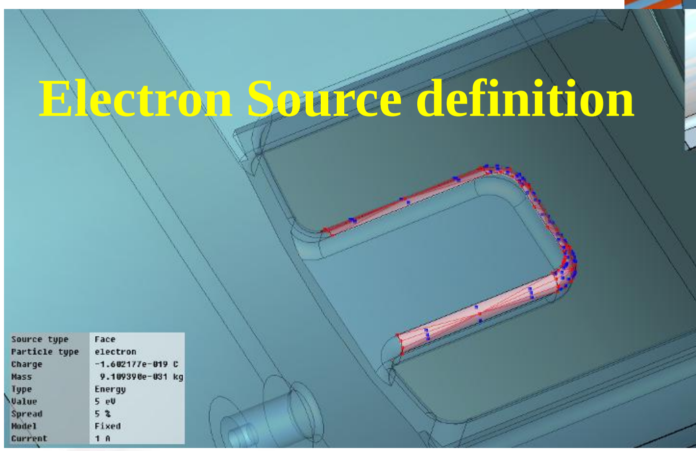


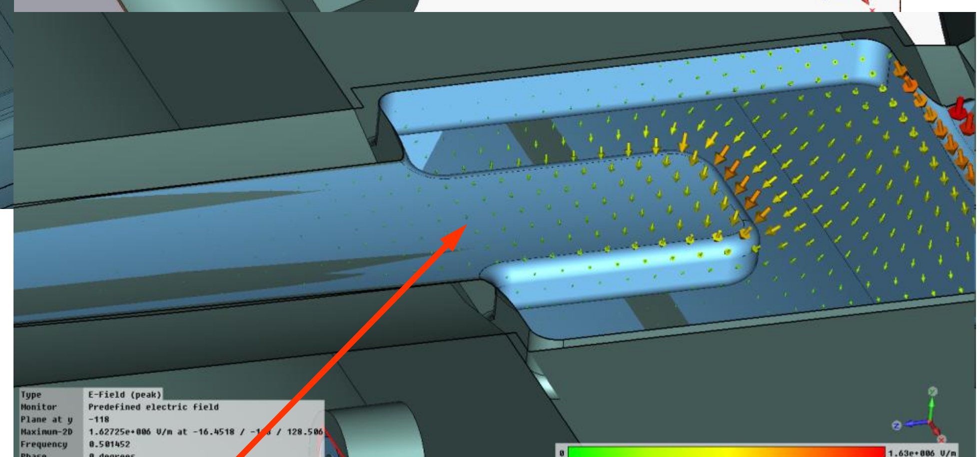
CST model for Multipactor study near Coupling tongue

Coupling tongue



Electron Source definition





TM010 E field from Eigen mode solver near coupling tongue

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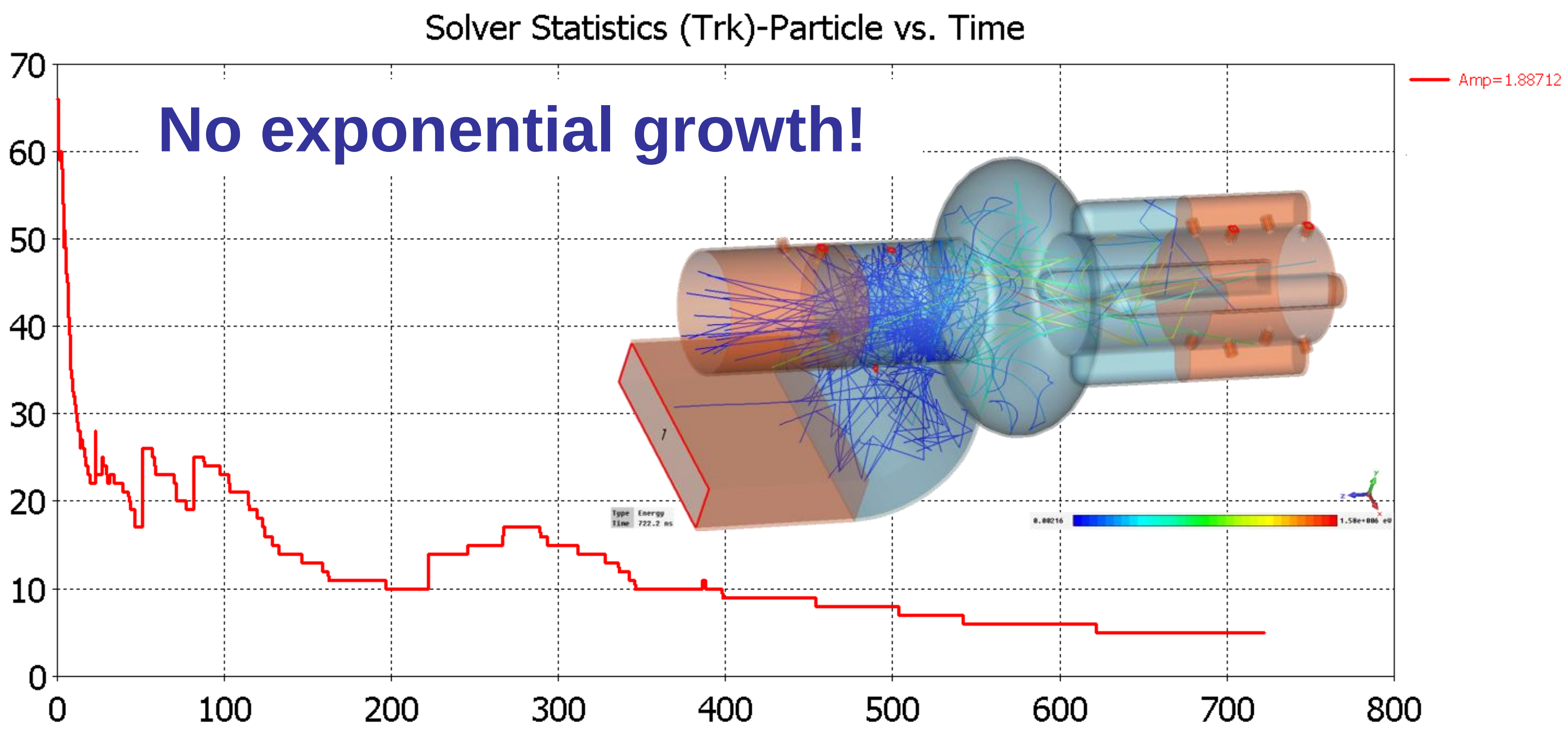
Preliminary tracking solver Results

Eigen mode field scaled to 1 MV across cavity



DLS IOT Upgrade from TED to E2V IOTs

TED IOT

E2V IOT

DLS IOT Upgrade from TED to E2V IOTs

- Successfully upgraded Systems 1 and 2 from TED to e2v IOTs during Christmas 2009 shutdown

Advantages

- Reduced IOT trips
- Simple tuning and setup with indexed settings
- Built in radiation shields no lead required
- Ion Pump readily recovers vacuum during initial filament start up

Differences

- Cavities built around IOT
- Cathode at the top inside the input cavity
- Network analyser not required for tuning

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Current IOT Operating Hours

	e2v S/N	Hrs in user operation	Hrs (Spares)	Hrs (Failed)	Status	Notes
IOT11	**224-0711**	2467				
IOT12	**290-0939**	996				
IOT13	**211-0647**	18976				
IOT14	**212-0647**	18839				
IOT31	**289-0938**	4269				
IOT32	**287-0931**	4264				
IOT33	**273-0907**	5624				
IOT34	**288-0935**	4265				
IOT22	**223-0710**	15327			Grid emmission	Waiting for grid outgassing
	210-0647	14853			Suspect	Under investigation for tripping
IOT21	**268-0851**		1040		Spare	
	205-0639			1219	Failed	During initial commissioning
	222-0710				Spare	Unused
	269-0904				Spare	Unused
	277-0909		510		Spare	

2009: 19 trips during 4300 operational hours (mostly TED IOTs)

2010: 9 x ISCs: 5 during initial run with new tubes
4 in a quick succession on single IOT

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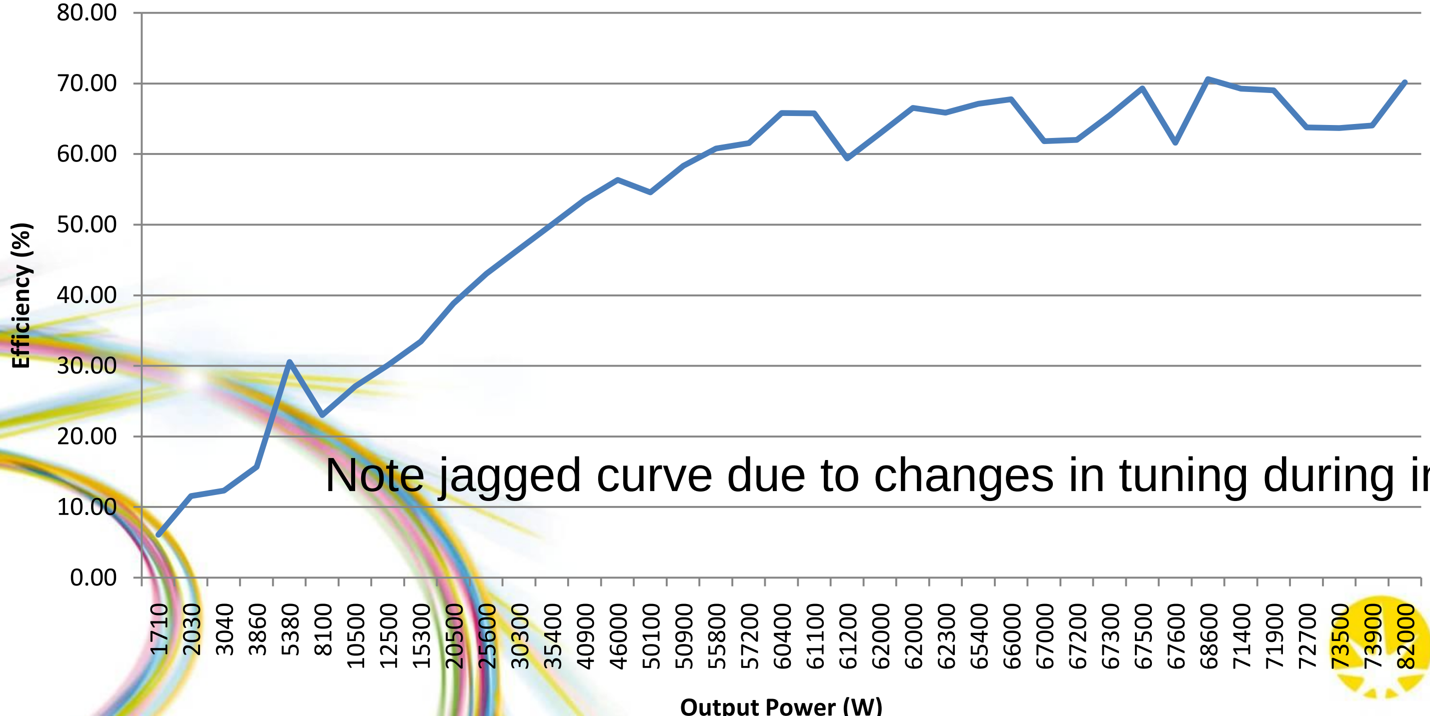
Typical Operating Conditions (S/N 268-0851)

HV (kV)	Pin (W)	Pout (kW)	I b (A)	Eff (%)	Gain (dB)	
-35	159	35	2.0	50	23.5	
-35	234	50	2.6	55	23.31	
-35	352	80	3.29	67	23.4	

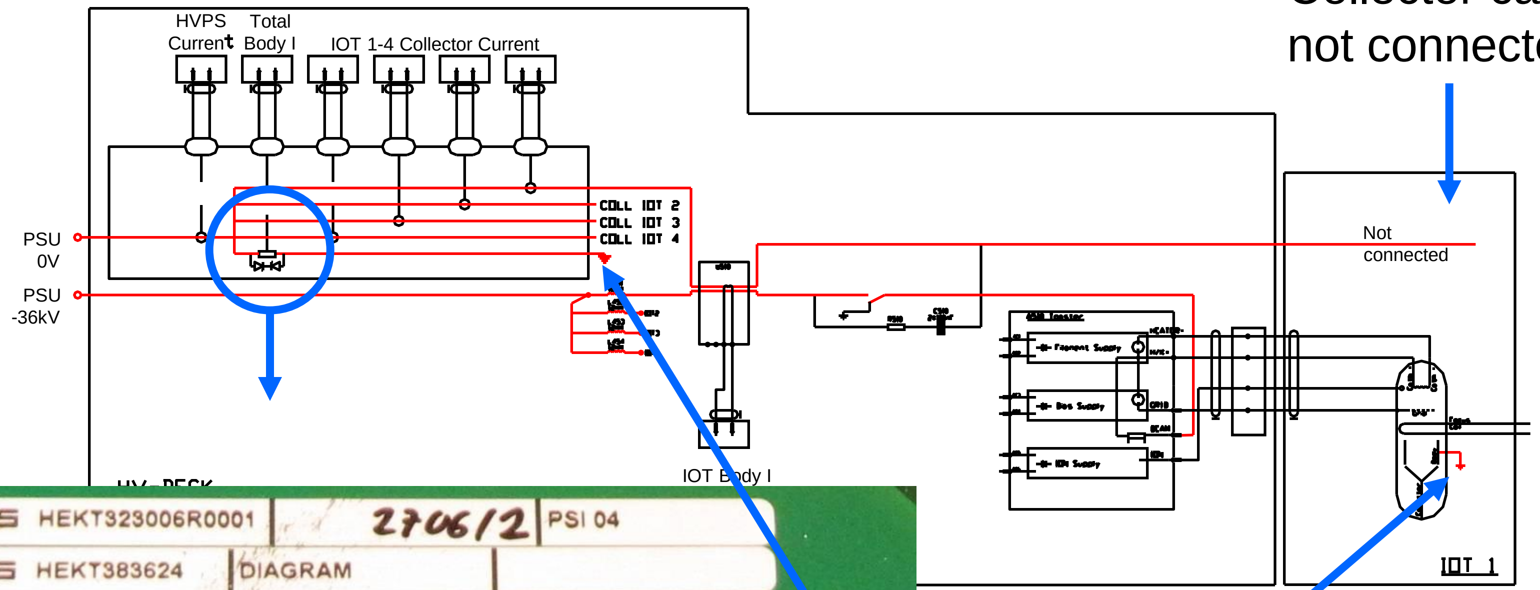
Efficiency During Initial Tune/Set Up (S/N 268-0851)

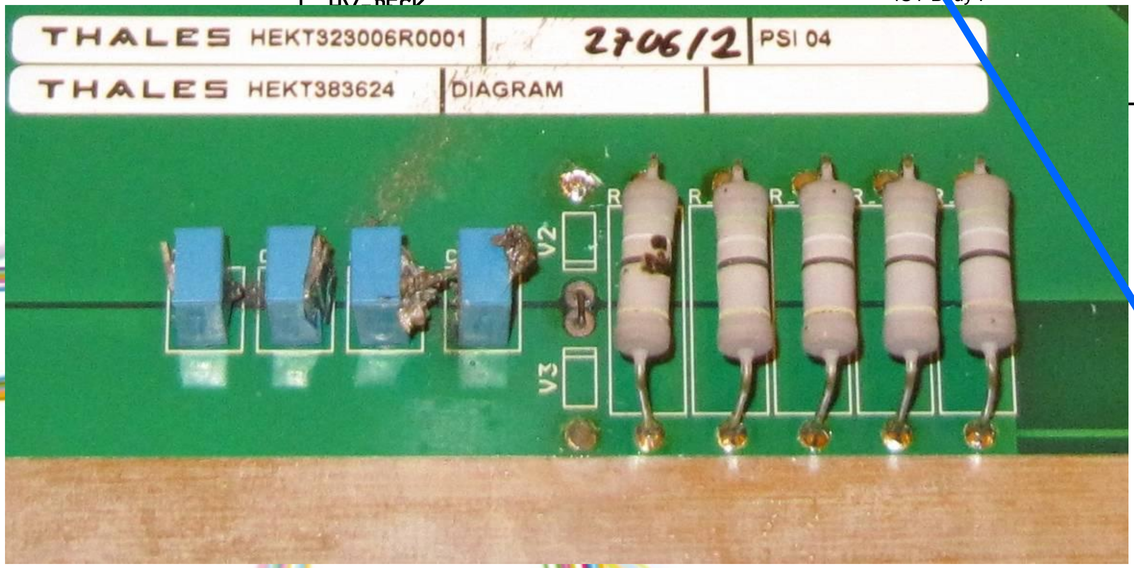


Note jagged curve due to changes in tuning during initial set up

Current measurement board affected by change from TED to E2V IOTs

Original e2v configuration





Collector cable not connected

-36kV return Now through IOT Body and HVPS I input

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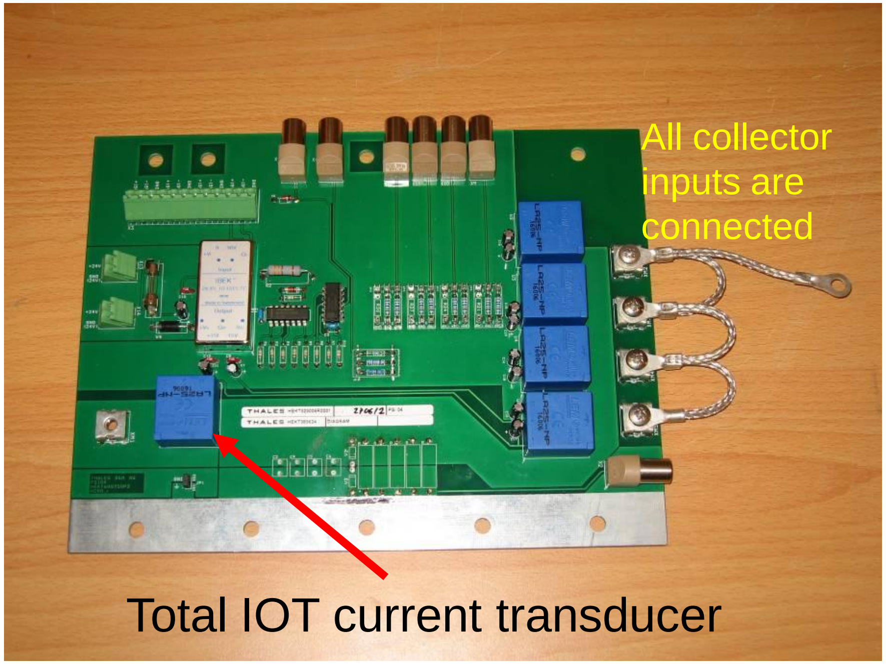
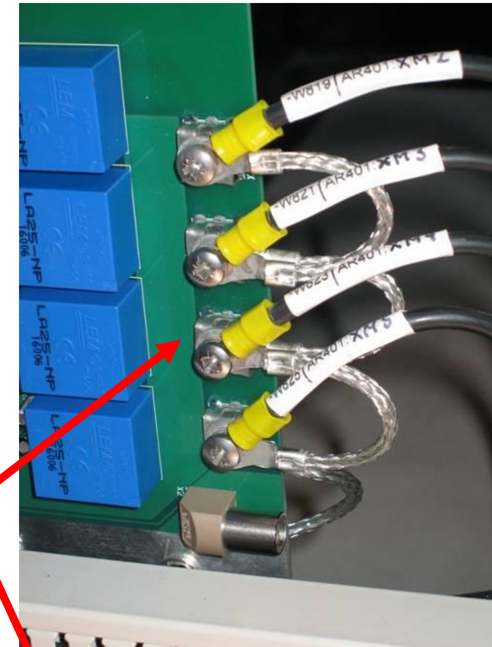
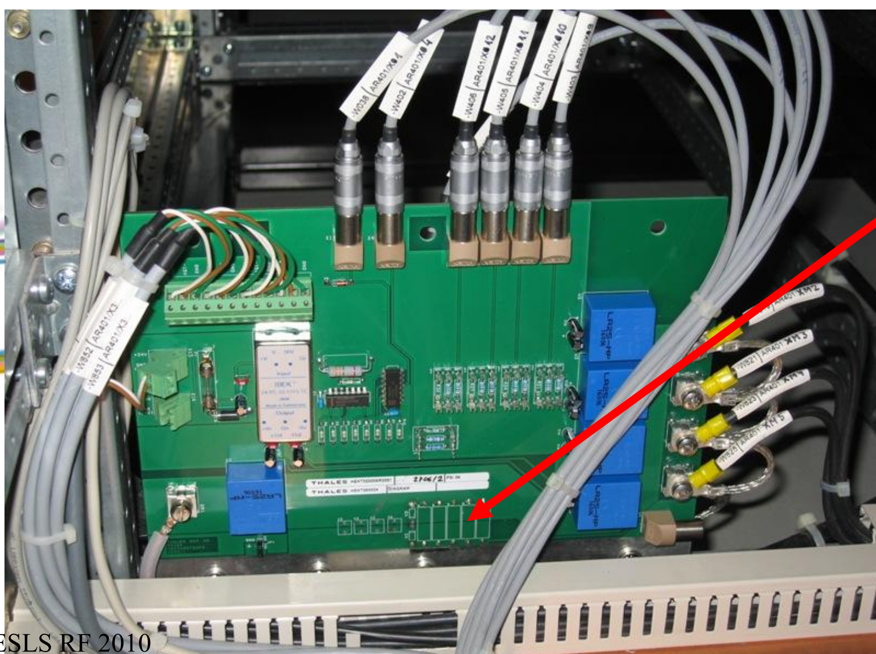
Current measurement board affected by change from TED to E2V IOTs

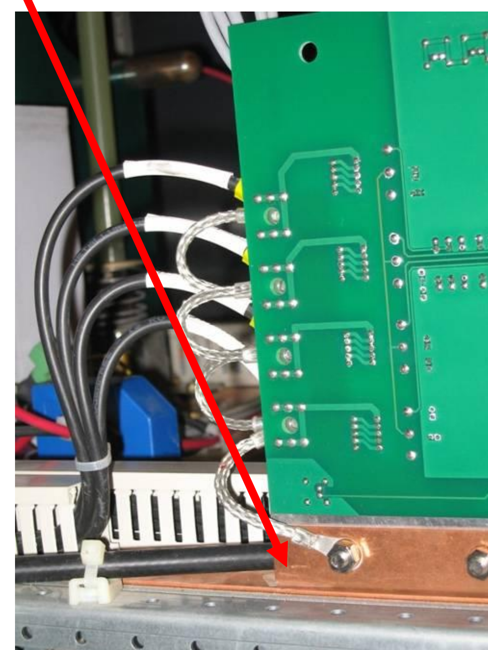




Earth current directed through IOT current transducers



Body current components removed

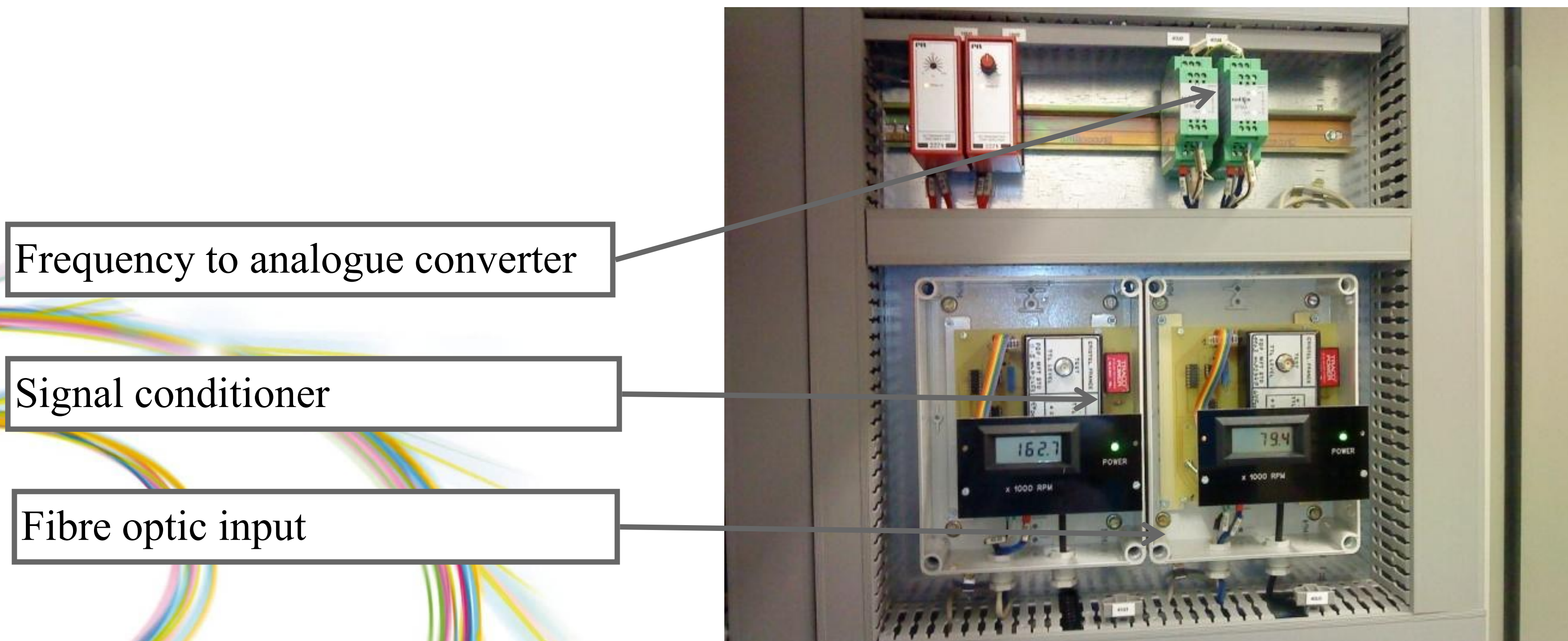


Problem:

Speed sensing of the warm turbine has occasionally become erratic without prior warning.

Repair:

After ensuring that the fibre optic cable was properly mounted, part of the signal conditioning box was changed.
The problem reoccurred. The frequency to analogue converter was then replaced. There has been no reoccurrence.



Thank you for your attention